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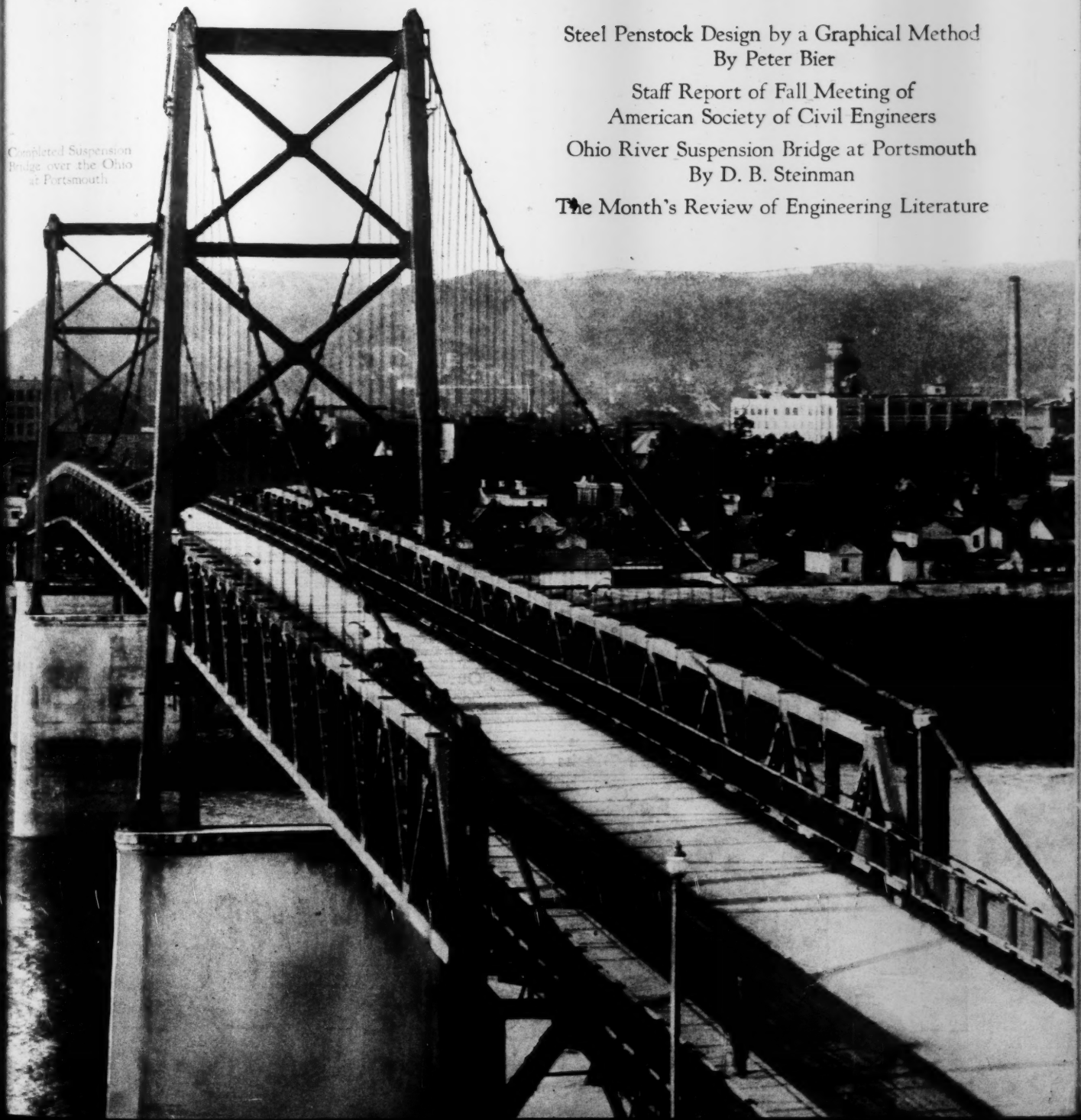

Completed Suspension Bridge over the Ohio at Portsmouth

Steel Penstock Design by a Graphical Method
By Peter Bier

Staff Report of Fall Meeting of American Society of Civil Engineers

Ohio River Suspension Bridge at Portsmouth
By D. B. Steinman

The Month's Review of Engineering Literature

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Volume 99 NEW YORK, OCTOBER 20, 1927 Number 16

Constructive Activity

IN A meeting of unusual character and strength, the American Society of Civil Engineers at Columbus last week gave evidence of constructive activity. The major problem before the country, the Mississippi River flood prevention problem, was the dominating feature of the meeting. Papers were presented by members of the Corps of Engineers and of the Mississippi River Commission, as well as by various engineers familiar with the Mississippi River and related problems, setting down the pertinent facts and outlining engineering methods used in the past and proposed to be used in the present instance. One aspect of this leading part of the program is discussed on the following page. But there were also important meetings of three divisions. In particular the structural division, in a program of notable strength, dealt with three subjects that are at the very forefront of structural development. The contribution made to knowledge of high building design by one of the papers is in itself an event, and demonstrates the vitality and activity within the society's ranks. In sum, the meeting gave bright promise of the future strength and usefulness of a great professional body.

Toe Erosion

WATER held the front of the stage at the Columbus meeting in other matters than the Mississippi River problem alone. The city's new water supply dam, the O'Shaughnessy dam, was described, and district water and sewage work in Ohio was discussed. In the course of these proceedings a point in dam construction was brought up that has very wide importance. It concerns a time-honored defect in the construction of overfall dams and spillways, one which has resulted in many losses in the past and promises to lead to more. It was brought to notice when Daniel W. Mead questioned the virtue of the ogee form of profile, used for the O'Shaughnessy dam. This type of profile directly invites erosion at the toe, and in fact there is a long record of troublesome erosion in front of overfall dams. The ogee form has the advantage of suppressing the free-falling sheet of water of the natural cataract or of the ordinary overfall, thereby avoiding troubles from air entrainment, vacuum formation, vibration and impact. But while yielding these benefits, it directs the downward gliding sheet forward in horizontal direction, and causes it to meet abruptly the slow-moving tailwater, forming here a hydraulic jump which inevitably has an erosive effect if the bottom is not exceptionally resistant. Commonly the attempt is made to protect the river bottom from such erosion by prolonging the ogee horizontally downstream in an apron, sometimes 80 to 100 ft. long. But except at very small overflow depths, the only effect of the apron is to preserve the flowing sheet unbroken, and transfer the jump to the forward edge of the apron, usually exposing or even undermining its toe wall in a short time. In one or two recent dams, as the Willwood irrigation dam, the apron has been built with a depressed pocket, the pool of water in which tends to localize the jump on the concrete, but general practice in smooth spillway design has not yet come around to recognizing this feature as essential. Toe erosion is sure to continue a frequent trouble and expense until this or other means are taken to remedy the shortcomings of the ogee profile.

Road Guides

EVIDENCE of the length to which state highway departments have gone in recognizing their obligations beyond building and keeping up main roads is furnished by two guide books which have recently come to the editor's desk. One of these guides is from Pennsylvania and the other is from Ohio and both are state highway department publications. Both tell the traveler of ways to go, of places to see, of the laws he must obey and of the signs erected for his guidance. These guides are convenient, definite, neatly printed and well illustrated. It was barely five years ago that state highway departments ventured tentatively to issue system maps periodically on which detours were noted. All states do not yet do this. In some the traveler is let alone to run into whatever conditions he may find. The progressive road building states, however, recognize that their obligation does not end in providing a path for the traveler. Publication of these state guides is a long step ahead of the first detour maps, very often turned out in the department's blueprinting room. It indicates how the doctrine is spreading that the physical ways themselves are but one of the agencies of carrying out the big task which is servicing and expediting traffic. This is the sole function of railway management; it is becoming the function of public roads management. One hopes to see many state highway department road guides with the coming years.

A Case for Review

AFTER tedious delay, the decision of the Secretary of War in the matter of the San Francisco Bay bridge was announced a few days ago. It is several months since the head of the Navy stated his department's opposition to locating any bridge north of Hunters Point, where it would either cross what is called the naval anchorage ground, or else span the wide channel through which ships reach the inner bay. His pronouncement was discussed in our issue of August 4 (p. 167) under the caption "More Naval Bureaucracy," at which time the facts of the situation were briefly outlined. It was expected that the Secretary of War would bow to the opinion of the Navy Department, and this week's announce-

ment is in accord with that expectation; the War Department states that it adheres to its past policy of declining to approve any bridge located north of Hunters Point. The case now has reached the stage where review by an impartial authority is in order. The War Department has shown itself to be anything but an impartial arbiter of traffic matters which involve navigation as one of the interested parties. It was never intended that the legal power over bridges should be so exercised as to ignore the legitimate requirements of land traffic, yet this is precisely what has happened time and again under the administration of bridge applications by the War Department. That department evidently regards itself as the special protector of navigation, to the point of preventing any decrease of the convenience of navigation whatever, no matter how strong may be the claims from the other side. The country's business has grown beyond the point where such an attitude is other than obstructive and damaging. The case of the Bay Bridge, we submit, is entitled to be taken out of the hands of the special friends of navigation and laid before a tribunal both competent and willing to weigh the question from the broad viewpoint of public interest.

National Obligations

IN ONE of the most brilliant meetings of its history, the American Society of Civil Engineers at Columbus last week gave proof of the fact that it recognizes its obligations to the public and is ready to meet them. Bringing together the civil engineers of the country in a comprehensive group, it is in a special position of fitness and privilege, and bears the commensurate responsibility of helping and safeguarding the community at large, when the need may appear, in great engineering undertakings that concern the nation. No greater task faces the country today than reclamation of the Mississippi River bottoms from flood dangers. How the task is to be performed is as yet an unanswered question. It was, therefore, most fitting that the society should take up the subject for consideration, as it did at Columbus.

In its essence, the Mississippi River problem is wholly one of engineering. It is true that questions of public policy occupy a critical position, but they themselves can be dealt with only as subsidiary phases of the engineering solution decided upon. Both the general nature of he problem and the quantitative data underlying it are still far from being definitely known. Under these circumstances, thorough discussion of the subject by the civil engineering profession is an obvious obligation. By taking a first step in this direction at the Columbus meeting, the profession has placed itself in readiness to serve further in working out the difficult task.

The problem at issue is complex, far too complex for quick solution. Present discussions therefore can be no more than a first step, and the problem is certain to be with us for a long time. It has not only intricate physical factors, but no less important human and political factors. The physical elements themselves are of unprecedented kind, since they concern one of the world's largest streams, valley conditions that are found nowhere else, and phenomena of hydrology and hydraulics that cannot be measured or interpreted by the experiences of other rivers. Moreover, methods are being proposed to deal with the present problem that have never been attempted before, here or elsewhere in the world.

We emphasize the responsibility of the civil engineering profession broadly in this matter, believing that no one fraction of the profession should be burdened with sole responsibility. Despite the name "civil," the military men, the members of the Corps of Engineers, are part of the profession and members of the society. For many years they have had the great river in their sole care, and they have discharged the responsibility with excellent zeal and continuity of purpose. They are now being placed under most severe criticism for permitting the flood disaster of the current year to come about, and more specifically for having failed throughout many years to recognize the magnitude of the situation under their charge. It is an occasion when the civil engineering profession as a whole may well come forward to support and assist the army engineers.

Offer of such assistance and support does not imply disregard of the merits of the Corps of Engineers. The Corps has made its record in uncounted works during its history. But the present problem is of unexampled scope, and as it concerns the whole nation most intimately no solution that does not utilize the thought of the whole engineering profession can be certain of meeting the situation. The American Society of Civil Engineers, representing the profession most broadly, has at its command the means for bringing into action all of the profession's thought on the subject, and by reason of this fact it is bound to be called to the council table before a final decision is made.

There are powerful human factors in the Mississippi River problem, as we have said; and, correspondingly, human emotions seek to enter the discussions. The engineer will need to give careful consideration to this phase of the problem, but he will also need to come back constantly to the physical facts and make his thinking accord with them. A suggestion of this particular difficulty came up at the Columbus meeting, in some remarks of the Secretary of War, who personally came before the assembled civil engineers to speak of Mississippi River reclamation. In the course of his remarks he stated what will doubtless prove to be the most troublesome element of the entire problem, namely, that of maximum flood possibilities. Speaking in the language of the executive, Mr. Davis asserted that the country must and will put a final end to such devastating floods in the Mississippi Valley as that of last spring. Mr. Davis knows, however, quite as well as does the engineer himself, that whoever attempts to play prophet to nature's future vagaries has no sure or peaceful occupation. He knows, too, that the floods of great rivers are apt to mock both the engineer's formulas and the lawgiver's decrees. His statement, then, may be taken as having forensic rather than technical meaning. Such statements as his may well serve to inspire a lofty purpose, but they must not be permitted to direct or warp conclusions. It is part of the engineering profession's obligation to be on guard here, and point the way to the truly practical result.

But if Mr. Davis made an impossible demand, nevertheless he held aloft an ideal which all the engineering planning concerned with the Mississippi River problem must take as its objective. He expressed what we believe is the sentiment of all the people: that all effort must be directed toward assuring lasting and confident security in the Valley. That is the great national obligation of the day. To meet this obligation is a task of supreme difficulty; it claims the united effort of the civil engineering profession.

Co-operation Comes to An End

NATIONAL adjustment of jurisdictional differences in the building industry appears to have been ended. When the Building Trades Department of the American Federation of Labor withdrew from the National Board of Jurisdictional Awards, as noted in *Engineering News-Record*, Oct. 6, p. 564, one of the most valuable instruments of arbitration was destroyed. For eight years the board has functioned, disposing of some 200-odd disputes of widely diverse nature. Most important, perhaps, has been the fact that pending settlement of all disputes work has gone on. There has been the minimum lost time and no legal jurisdictional strikes.

The National Board of Jurisdictional Awards was set up as an instrument of arbitration largely through the appeal of the labor federation's Building Trades Department. It is composed of eight members—three selected by the Building Trades Department, two by the Associated General Contractors, and one each by the American Institute of Architects, American Engineering Council and the National Building Trades Employers' Association. It has held regular meetings quarterly. Two years after its organization the carpenters withdrew because placement of metal trim was awarded the sheet-metal workers. The carpenters refused to appear at the hearing, in direct opposition to the orders of the Building Trades Department. The militancy of the carpenters at this decision is a matter of public record. Even after their withdrawal the board entered, according to its chairman and one of its staunchest friends, Rudolph P. Miller, "a period of real usefulness." Such disputes as needed intimate investigation were referred to committees and the board took their reports into full account when decisions were rendered. Little time was lost in the adjustments of controversies and the board appeared as a sober-minded and responsible arbiter. Undoubtedly its decisions have saved millions of dollars to the construction industry, and saved much worry to engineer, contractor, architect and mechanic alike.

Now comes the withdrawal of the entire Building Trades Department, numbering some 1,200,000 men, from the board. Decision to withdraw has been prefaced by extensive arguments among the trades involved that withdrawal is highly desirable. The board is accused of frequent reversal of opinion, "inconsistent rulings," and unfair decisions. The Building Trades Department charges prejudice against certain unions by members of the board, and laxity in enforcing decisions. Specific cases such as the awarding of opalite, the Cleveland mantel case and the decision on the placement of concrete roofing slabs are pointed to by the unions as just grounds for withdrawal. However, neither the charges nor the briefs urging withdrawal from the board are particularly convincing.

One must consider that in setting up such a broad arbitration mechanism time must be had in which to judge of its general effectiveness. Two years may have convinced the carpenters that withdrawal was desirable, and eight years the rest of the building trades, but placed against their objections is the weighty fact that much valuable time and millions of dollars have been saved. New materials are constantly being brought forward for construction uses. Decision as to their placement has been an important function of the Board. Now, with its authority nullified the board must dissolve, and one can expect a vast economic loss when disputes drag on through lack of a properly constituted authority to settle them. These aids to mechanical construction will continue to be produced, but, lacking some new and efficient agency, their placement will be claimed or repudiated, as the case may be, by the trades most vitally involved.

It is inconceivable that a board composed of such sober-minded men as are the various organization representatives on the National Board of Jurisdictional Awards could be guilty of the petty charges directed at them by the Building Trades Department. It must be set forth here, then, that with the evidence one cannot help but feel that a valuable agency has been wantonly destroyed, and that large losses of time and money are certain to result.

Typhoid Blame at Montreal

RECENT news of interest regarding the Montreal typhoid epidemic relates to responsibility for its cause and long continuance. Instead of addition to the knowledge on this subject the aim and accomplishment of the city council is secrecy. A recent flare-up in the council in favor of an investigation was smothered by a 2 to 1 vote. Apparently the motive of those who wished an investigation was to place responsibility as between the legislative and administrative branches of the city government. An executive committee of the council seems to have large administrative power, and for this or some other reason, presumably political, appears to dominate the council.

During the agitation for an investigation the director of the city health department received blame that apparently should have been put on both the council and its executive committee. The health director seems to have done all he could to control the epidemic. He lacked men, money and authority from the council to do what he knew was needed.

Despite orders from the provincial health department, neither the council nor its executive committee raised hand or voice for the closing of the dairies responsible for the epidemic.

In attempted self-defence the council urged that closing the dairies might cause damage suits, and that it was uncertain anyway whether the council or its executive committee had power to act, if action were to be taken. This, when scores of typhoid cases were being reported daily. The council is under suspicion for refusing to act and holding back the health director from acting to stop the epidemic lest some of the councilmen or their backers be hurt financially and the councilmen be hurt politically as well. The fact remains that the exact cause of the epidemic, or at least the way milk supposed to be pasteurized carried infection for weeks after it was under strong suspicion if not certainty of danger, and the reasons why no action on this knowledge was taken, are either still shrouded in mystery, or are not openly acknowledged.

The wonder is, since the city authorities fail to function, that some organization of medical men, or engineers, or some commercial or civic organization, or some group of strong men and women independently of any organization, if none of these have the sense of civic duty and the courage to act, does not speedily set on foot at Montreal an investigation that would go unsparingly to the bottom of this worst typhoid epidemic of the century, disclosing whatever rottenness there is—and rottenness there must be—as to its cause and its long continuance.

Ohio River Suspension Bridge at Portsmouth

Highway Crossing of 700-Ft. Span Just Completed—Earlier Suspension Bridges in the Ohio Valley—Rocker Towers and Continuous Trusses—Cable Strands Laid Up on Shore

By D. B. Steinman
Robinson & Steinman, Consulting Engineers, New York

THE commencement of a new period of suspension bridge construction in the Ohio River territory is marked by the approaching completion of the "General U. S. Grant Bridge" between Portsmouth, Ohio, and Fullerton, Ky. The outcome of the bidding competition on alternative designs for this crossing has caused the suspension type of modern design to become accepted as the economic and efficient type of bridge for Ohio River spans. Within a year, four or more new projects for bridging the Ohio have been started—all suspension designs.

The Portsmouth suspension bridge is of further interest because of a number of unusual features. In general design, it departs from conventional practice in the use of a continuous stiffening truss, rocker towers, rocker bents for supporting the cables, and sand-filled anchorages. In details, it embodies novel features in the expansion connections, in the adoption of forged cable bands, in the splicing of stringers for continuity, and in the railing design. In construction, the method of spinning and placing the cables and the method of erecting the stiffening trusses were unusual.

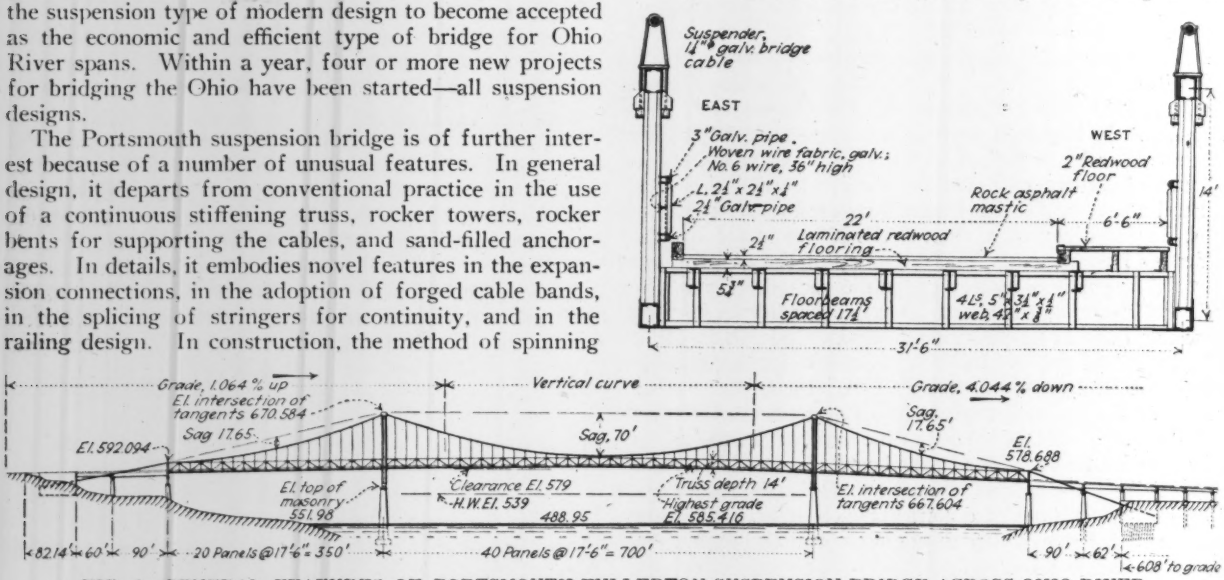


FIG. 1—GENERAL FEATURES OF PORTSMOUTH-FULLERTON SUSPENSION BRIDGE ACROSS OHIO RIVER

Some Predecessors—The earliest bridges built over the Ohio River were suspension spans. The history of suspension bridge construction in the Ohio territory divides into three distinct periods. The first, extending from 1848 to 1871, was a pioneer period, distinguished by the work of Ellet and Roebling. Its outstanding bridges were:

BRIDGES OF PIONEER PERIOD

Date	Location	River	Span, Ft.	Remarks
1848	Wheeling, W. Va.	Ohio	1,010	Still in use
1848	Guyandot, W. Va.	Guyandot	450	Still in use
1852	Charleston, W. Va.	Elk	478	Failed 1904
1855	Morgantown, W. Va.	Monongahela	608	Still in use
1867	Cincinnati, Ohio	Ohio	1,056	Still in use
1871	Warren, Pa.	Allegheny	470	Still in use

Ellet's bridge at Wheeling was a record-breaking structure, being the first span ever built exceeding 1,000 ft.; it failed in 1854 from inadequate stiffening and lack of wind bracing, and was repaired the same year by Roebling; again rebuilt in 1861, it is still in service after eight decades. The Elk River bridge at Charleston also had a checkered career; built at a total cost of $19,000, it was twice disabled by retreating armies during the Civil War; after being declared unsafe, it collapsed under a load of ice and snow in 1904. Roebling's 1,056-ft. span at Cincinnati was his greatest work prior to the Brooklyn Bridge; it was strengthened in 1898 by Hildenbrand, and is still in service carrying a heavy live-load including street cars.

Then followed an interval of 25 years during which no wire cable bridges were built over the Ohio River or its tributaries. However, two "eyebar" suspension bridges were built over the Allegheny River at Pittsburgh: Hemberle's Point Bridge (800-ft. span) in 1877, and Lindenthal's Seventh St. Bridge (330-ft. spans) in 1884; both of these were replaced by other structures in 1926-7.

The second or intermediate period, 1896 to 1905, covered the work of Laub and his followers. The bridges built during this brief period of activity included:

BRIDGES OF INTERMEDIATE PERIOD

Date	Location	River	Span, Ft.	Remarks
1896	East Liverpool, Ohio	Ohio	705	Still in use
1897	Rochester, Pa.	Ohio	800	Still in use
1903	Caperton, W. Va.	New	510	Still in use
1905	Steubenville, Ohio	Ohio	705	Still in use
1905	East Liverpool, Ohio	Ohio	750	Still in use

The suspension bridges of this intermediate period were characterized by a general similarity of design, following the pattern set by Laub. The one-hinged stiffening truss was the favored type; combined restraint and continuity of the truss at the towers rendered the stresses scarcely calculable, and the center hinge gave rise to a pronounced peak or valley in the roadway grade with rise and fall of temperature. Suspender rods were made adjustable, but their proper adjustment was

neglected. Probably as a result of keen economic competition, sections and details were used that today would not be admissible. Although the theory of suspension bridge analysis was then available, the stiffening trusses were apparently proportioned by rule-of-thumb, with the same section used from end to end and for different spans. When the writer's firm was retained to report on the Steubenville bridge, following a crumpling failure of its stiffening truss under passing load in 1923, the calculations revealed stresses exceeding 100,000 lb. per sq.in. producible in the truss chords by the original design loading, and a stress of 70,000 lb. for the actual loading at the time of the failure. The report recommended reinforcement of the structure, but action was deferred until a second crumpling failure occurred the following year. The original cost of the bridge was about $200,000, but it could not be duplicated at the advanced prices for less than $600,000; for an expenditure of $75,000, the bridge has now been made safe and serviceable for modern loadings including an electric railway.

After 1905, suspension bridge construction in the Ohio valley suffered a long interruption, perhaps partly because of the failure of the Charleston bridge a year before. With the single exception of the bridge at Parkersburg, built by Laub in 1916, no suspension bridges were built over the Ohio during the interval from 1905 to 1927. The cantilever type flourished, though it appears to be limited to this interval. The list includes:

OHIO RIVER CANTILEVER BRIDGES

Date	Location	River	Span, Ft.
1903	Marietta, Ohio	Ohio	650
1904	Pittsburgh, Pa.	Monongahela	812*
1904	Mingo Jn., Ohio	Ohio	700*
1910	Beaver, Pa.	Ohio	769*
1911	Sewickley, Pa.	Ohio	750
1917	Steubenville, Ohio	Ohio	660
1922	Ironton, Ohio	Ohio	725
1925	Huntington, W. Va.	Ohio	700

* Railway bridges.

In connection with the foregoing group of bridges, mention should also be made of the Sciotoville continuous bridge with two 775-ft. spans, built over the Ohio in 1916; it is also a railway bridge.

The modern period of suspension bridge construction in Ohio River territory commences with the adoption of this type for the Portsmouth bridge. Following two decades of almost exclusive adherence to the cantilever, the pendulum has swung back to the suspension type and practically all of the new Ohio River spans begun or projected (1927) are designed to be suspension bridges. Following the Portsmouth bridge, new suspension bridges

FIG. 2—CABLE STRAND LAID UP ON SHORE AND HOISTED TO TOWER COMPLETE
Truss erection was handled by derrick scow with 150-ft. boom.
Upper left—finished strands. Upper center—shoe end of strand on truck ready for moving to bridge. Lower left—guide sheave on scow for taking strand across. Lower right—raising strand to saddles.

are planned or under construction at Point Pleasant, W. Va.; Steubenville, Ohio; Maysville, Ky.; and Pomeroy, Ohio. Some of these are patterned after the Portsmouth bridge. In the case of the Point Pleasant bridge, otherwise similar in design, a departure was introduced by the adoption of eyebar chains, following the receipt of an alternative proposal for this material in the recent bidding; it will therefore be the second suspension bridge to employ high-strength heat-treated eyebars, the Florianopolis bridge being the first.

Competition of Types—The Portsmouth bridge was undertaken as a toll bridge project by the Portsmouth-Fullerton Bridge Co. The official design, prepared by The J. E. Greiner Co., was a cantilever bridge with a compete with the cantilever for spans as small as 700 ft. Where local conditions especially unfavorable to the economy of the suspension type do not obtain, it can compete with the cantilever for much smaller spans. Comparative estimates in fact show the suspension type to be economical for spans as small as 400 ft.

Principal Dimensions—As built, the Portsmouth bridge has a main span of 700 ft. and two side spans of 350 ft. each. The main cable sag is 70 ft. or 1:10 of the span; the side-span sag was made 17.65 ft. in order to equilibrate the cable under full dead-load. The stiffening truss was made 14 ft. deep, or 1:50 of the span length, determined by the degree of rigidity desired.

To provide a clear roadway of 28 ft. the spacing of

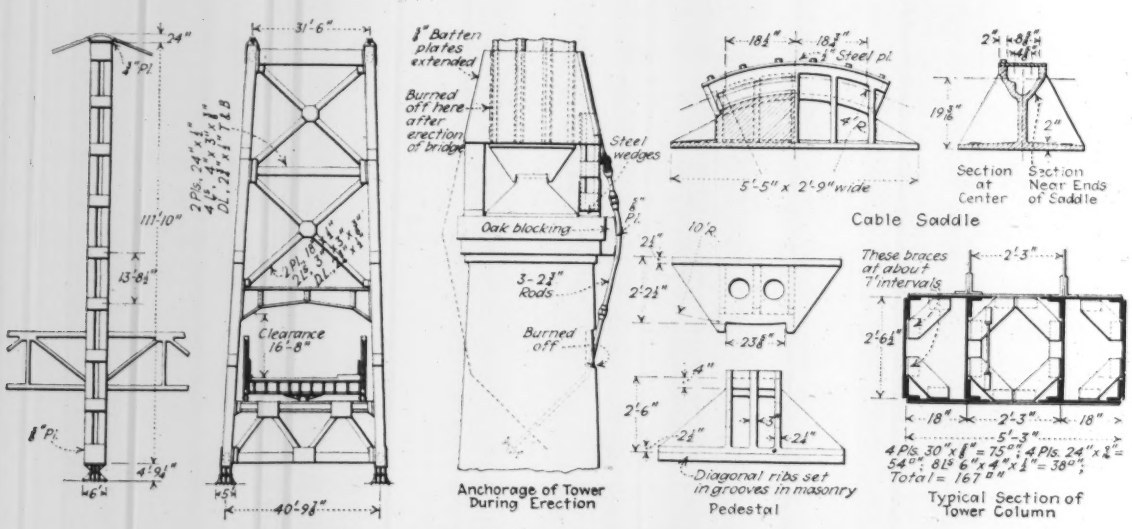


FIG. 3—ROCKER TOWER AND BEARINGS
Tower stayed during erection by struts and ties to pier

main span of 700 ft. This was identical in span and otherwise similar in design to the bridge then approaching completion at Huntington, W. Va. The Dravo Contracting Co., which was interested in the bridge both as part owner and as prospective contractors, retained the writer's firm to prepare an alternative design of the suspension type for the purpose of bidding, the loadings, unit stresses and other governing conditions being agreed upon in conference between the two engineering firms. Three bids were received on the cantilever design, but the Dravo bid (the only bid) on the suspension design was 10 per cent under the lowest bid for the cantilever. The suspension design was accordingly adopted.

In this instance the suspension type was handicapped by unfavorable local conditions. The topography and the existing railroad tracks interfered with the customary location of the anchorages at the ends of the suspension structure, without a material increase in the length of the main structure. The problem was solved partly by lengthening the side spans from 275 to 350 ft., and partly by placing the anchorages 150 ft. away from the ends of the side spans. This necessitated lengthening the cables and carrying them an idle distance of 150 ft. at each end, and providing cable-supporting bents that would otherwise have been unnecessary.

Despite these handicaps there remained sufficient inherent economy in the suspension design to make it successful in the competition. This result has served to correct an impression that the suspension type cannot

the trusses was made 31½ ft. The cables are hung in the truss planes. The width of the towers increases from this saddle spacing at the top to 40 ft. 9⅞ in. at the base, corresponding to an adopted batter of ½ in. per foot for the tower legs. This form of tower, with main legs battered, was introduced into suspension bridge practice by the writer's partner, H. D. Robinson, having been recommended by him in 1911 for the proposed Rhine bridge at Cologne and first applied by him in 1919 in the design of the Rondout Bridge at Kingston, N. Y., completed 1922, the object being to provide clearance for roadway and stiffening truss without interference by the tower columns, incidentally securing the advantage of increased transverse stability.

Continuous Stiffening Truss—The Portsmouth bridge is the second American suspension bridge built with a continuous stiffening truss; the first application was made in the design of the Rondout bridge. The continuous truss was adopted because it offers greater efficiency than the conventional two-hinged type. This increased efficiency may be in the form of superior economy, or superior rigidity, or both, depending upon the proportions adopted. Comparative designs show that the continuous type is more rigid for the same total quantity of steel, and more economical for the same specified degree of rigidity. It offers incidental advantages in greater efficiency of the continuous lateral truss, in improved and simplified supporting details at the towers, and in reduced variation between minimum and maximum sections.

In the Portsmouth stiffening truss, the variation of chord sections is from a minimum of 24.3 sq.in. (at the L_0 end of the side spans, and near the $\frac{1}{6}$th points of the main span) to a maximum of 33.8 sq.in. (at the towers and at mid-span). Only two intermediate sectional areas were required. All chord sections were made up of two 15-in. channels (34, 40, 45, or 50 lb.) with top cover plate 12x$\frac{3}{8}$ in. Instead of bottom lacing, 9x$\frac{3}{8}$-in. batten plates at 3-ft. spacing were used. All diagonals are made up of two 10-in. 20-lb. channels, tied together with batten plates, except in the panels adjoining the tower, where 12-in. 25-lb. channels were necessary.

Rocker Towers—The Portsmouth bridge is the first suspension bridge to be built in this country with towers of the rocker type. (The Florianopolis bridge, also designed by the writer's firm, was the first application of rocker suspension towers outside of Europe.) This type was adopted because it is believed to be the most scientific and most economical. It yields a substantial saving in main material of the tower (by eliminating the bending stresses caused by tower deflections), in the pedestals at the base, and in substructure; and it minimizes the difficulty and expense of pulling the towers back toward the shores during the erection of the cables. The main pier shafts, only 8 ft. in diameter under coping, could not have served for towers of the fixed-base type.

The Portsmouth towers, like those of the Florianopolis bridge, rock on line bearings 33 in. long, between upper and lower steel castings. The upper casting, secured to the tower leg, has its bottom face finished to a convex surface of 10-ft. radius. The lower casting, secured to the masonry, has its top finished to a plane surface. This line bearing has to carry a reaction of 1,000 tons per tower leg. Flanges hold the castings in proper relative position, and the lower casting has diagonal ribs set in grooves in the pier concrete for security against displacement, supplementing the anchor bolts.

To hold the towers during erection, the batten plates at the base of each column were extended and formed into wing-brackets; under these, small steel struts were wedged up on the pier masonry, while each bracket was tied to the pier by three $2\frac{3}{4}$-in. hog-rods. After the cables were in place the towers were freed at the base by burning off the temporary extensions of the base batten plates.

Each tower leg is made up of two closed box sections, tied together at intervals with batten or splice plates. This section is exceptionally efficient, yielding a radius of gyration of 23 in. with a sectional area of 167 sq.in. Manholes and ladders are provided to give access to the interior of the columns; and the section is stiffened with interior diaphragm bracing at suitable intervals.

The basic unit stress of 18,000 lb. per sq.in., reduced by column formula and increased 25 per cent for inclusion of wind stress, yields a permissible unit stress of 17,700 lb. per sq.in. for the tower columns. The actual stress (11,700 from load, 1,000 from wind and 4,600 from portal flexure) is 17,300 lb. per sq.in.

At each end of the suspension structure is a rocker bent to support the cables at the point where they bend downward on their way to the anchorage 150 ft. away.

In addition to sustaining the cable reactions, the rocker bent has to support the reversible end-reactions of the continuous stiffening truss, and the end-reactions of the 90-ft. approach girder span. Rocking action is necessitated by the thermal and elastic elongation of the cables between anchorage and top of bent. The difference of cable tension on either side, corresponding to the difference of cable inclination, necessitates provision for fixing the cables against sliding in their saddles at the top of the bent. The rocking of the tower, combined with the expansion of the main structure and of the approach span, necessitated sliding or rocking details for the respective end bearings.

The legs of the rocker bent are vertical, about 32 ft. high; they rest on pier bases and carry cable saddles at their tops. To permit the end of the stiffening truss to pass through the column, the cover plates are interrupted; sliding pin bearings transfer the truss reaction directly into the column. The approach girders are seated on a transverse truss connecting the two columns below the bridge deck.

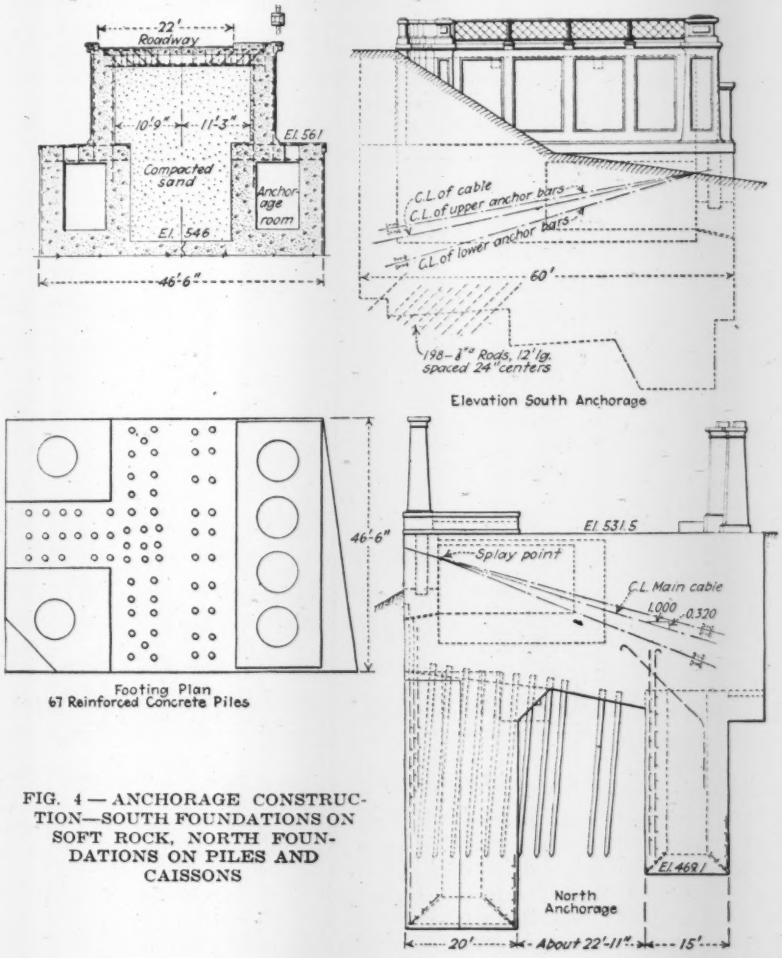


FIG. 4 — ANCHORAGE CONSTRUCTION—SOUTH FOUNDATIONS ON SOFT ROCK, NORTH FOUNDATIONS ON PILES AND CAISSONS

Design of Cables—For the cables of the Portsmouth bridge, bright wire was adopted instead of the more customary galvanized wire, on account of the faith of the designing engineers in the adequacy of the protection afforded by modern cable wrapping. The bright wire yields advantages of lower cost and greater strength. The cables of the Williamsburgh bridge, made of bright wire, are in an excellent state of preservation. When Roebling's Niagara railway suspension bridge was taken down (after a half-century of severe service under increasing locomotive loading), the bright wire composing the cables was found free from rust. Except possibly for coastal locations exposed to salt air, the writer would unhesitatingly recommend the use of ungalvanized wire for bridge cables; with the proviso, of course, that the outside of the cables be suitably protected with tight wire wrapping.

When the design was prepared, the conventional method of spinning-in-the-air was contemplated for the Portsmouth cables (though later another method of construction was adopted). In order to avoid difficulty in the air-stringing arising from the stiffness of the wires in so short a span, such as was encountered in the cable stringing for the 705-ft. span of the Rondout Bridge, it was decided to adopt smaller wire—No. 8 of 0.162-in. diameter, in place of the usual No. 6 wire of 0.192-in. diameter. Three strands, each containing 486 wires, made up the required 30 sq.in. per cable. Each strand terminates in strand-shoes which are pin-connected to the anchorage eyebars. After the three strands were squeezed together (this was done by three-plunger hydraulic squeezing machines devised by H. D. Robinson) the cable had a diameter of $7\frac{1}{8}$ in. under the wrapping wire. The cables were wrapped with No. 9 soft annealed double-galvanized steel wrapping wire, by an electrically operated cable-wrapping machine, also the invention of Mr. Robinson.

The wire for the Portsmouth cables was specified to have a minimum yield-point of 140,000 and a minimum ultimate strength of 220,000 lb. per sq.in.; the tested strength averaged over 230,000 lb. per sq.in. The adopted working stress was 70,000 lb. per sq.in. for the initial condition of the bridge (22-ft. roadway and inside sidewalk), and 80,000 for the possible future condition of the bridge (28-ft. roadway and outside sidewalk). In this connection, the writer wishes to record his conviction that suspension bridge designers have been too conservative in the past in fixing wire cable working stresses, in comparison with working values permitted for other materials, and that stresses as high as 100,000 lb. per sq.in. or even higher may safely be used for this unexcelled bridge material.

The maximum horizontal tension per cable, for the ultimate bridge loading is 2,158,000 lb. (1,530,000 dead-load, 548,000 live-load, and 80,000 lb. temperature), and the maximum inclined tension 2,380,000 lb., which is slightly under 80,000 lb. per sq.in.

The suspender at each panel point consists of two parts of $1\frac{1}{4}$-in. diameter double-galvanized steel bridge cable, stranded 6 by 7, with a steel wire rope center. This suspender rope weighs approximately 2.57 lb. per lin.ft., and has a guaranteed minimum breaking strength of 62 tons. The calculated maximum panel concentration (including impact) is 79,400 lb., so that a factor of safety exceeding 3 is provided by these suspenders.

Departing from conventional precedent, the suspenders of the Portsmouth bridge were made *non-adjustable*. It was deemed preferable to depend upon scientific precalculation of correct suspender lengths and careful measurement in cutting and socketing, than to place reliance upon variations of field adjustment. In the investigation of the old Steubenville bridge, the writer's firm found individual suspender rods as much as 5 in. out of adjustment, with a consequent stress-distortion of the structure by that amount between adjacent panel points. Non-adjustable suspenders are a protection against future accidental or misguided disturbances from correct adjustment.

The attachment of the suspender ropes is made by means of their button sockets bearing under angle lugs riveted to the truss posts near their tops.

Design of Anchorages—The outstanding novel feature in the Portsmouth anchorages is their design as large reinforced-concrete boxes filled with compacted sand as an economical means of producing mass resistance; this use of sand-filled chambers yields a material saving of concrete. The only previous application of such a feature was in the suspension bridge at Massena, N. Y., 400-ft. span, designed and built by Mr. Robinson in 1910.

The south or Kentucky anchorage, which also serves as end abutment, is founded on hard blue shale; this

FIG. 5—END OF KINKED STRAND
This strand was successfully straightened.

was stepped off, with top slopes of 1 to 6, to increase the resistance to cable pull; in addition, about two hundred $\frac{7}{8}$-in. rods, 12 ft. long, were driven into the rock at 45 deg. under the heel of the anchorage, to serve as dowels for greater security. The anchorage weight comprises 3,800 tons of concrete and 1,600 tons of sand; the latter contribution represents a saving of 800 cu.yd. of concrete.

The Ohio anchorage, similar in general principle of design, which differs slightly in shape for local reasons, has caisson and pile foundations, as rock did not occur near the surface. Three caissons were sunk by open dredging: one under each corner of the toe through 45 ft. of clay to hardpan, and one under the full length of the heel through 27 ft. of clay to a bed of sand and gravel. In the T-shaped area between these caissons, 67 reinforced-concrete piles were driven, on an average batter of 1 in. per foot.

Roadway Design—The Portsmouth bridge is designed and proportioned for an ultimate three-lane roadway, 28 ft. wide between curbs, and a future 6-ft. sidewalk on

outside brackets. Pending the development of increased traffic demands, a part of the roadway space is utilized for an inside sidewalk, 6½ ft. wide.

The roadway floor is of asphalt on a laminated redwood base. The redwood planking, set on edge across the stringers, is alternately 5¼ and 5¾ in. high, so as to yield a more effective bond with the asphalt wearing coat; the latter is of rock asphalt mastic and has a minimum thickness of 2½ in. above the higher planks.

This floor construction of asphalt on redwood base is lighter (though not cheaper) than a reinforced-concrete floor, resulting in a saving of material in the supporting structure. It was adopted for the suspension design of the Portsmouth bridge in the bidding competition because the same floor construction was proposed in the official cantilever design. If a concrete floor had been adopted for both competing designs, the suspension design would have enjoyed an easier victory; for the suspension type is less affected in cost by dead-load than any other bridge type (the stiffening truss sections are not increased, but actually somewhat reduced, by an augmentation of the design dead-load).

Loads and Stresses—The floor system of the Portsmouth bridge was designed for a maximum load of a 20-ton truck at any point, or for a normal load of three 15-ton trucks abreast. Impact of 37½ per cent was added in proportioning the stringers, and of 30 per cent in proportioning the floorbeams.

For the design of the stiffening trusses, cables, towers and anchorages, the assumed live-load was a uniform load of 1,400 lb. per lineal foot of bridge plus a superimposed concentrated load of 42,000 lb. at any point. The uniform load represents three lanes of motor vehicles averaging 50 lb. per sq.ft., and the concentration represents the excess weight of three 15-ton trucks abreast at any point in this stream of traffic.

The estimated dead-load (per cable) used in the stress calculations for the final condition of the structure (with 28-ft. roadway and outside sidewalk) was 1,748 lb. per lin.ft. (flooring and sidewalk 674 lb., floor steel and railings 551 lb., trusses and bracing 387 lb., cables and suspenders 136 lb.). These figures are for the east cable; the dead-loads for the west cable are somewhat less in consequence of the unsymmetrical cross-section of the bridge.

The design loading also included a moving wind load of 30 lb. per sq.ft. on 1½ times the vertical projection of the structure, and a temperature variation of ± 60 deg. F.

Unit Stresses—The structural steel used is medium carbon steel of minimum elastic limit 36,000 lb. per sq.in. and ultimate strength 60,000 to 70,000. A basic unit stress of 18,000 lb. per sq.in., reduced for compression, was adopted for the towers, floor system and approach spans, and 24,000 for the stiffening truss (with column reduction and a limiting value of 21,000 for compression). The higher basic stress for the stiffening truss is justified by the fact that the truss is not essential for the safety of the structure against collapse.

In accordance with the usual practice, it was specified that the basic unit stresses for proportioning the towers and stiffening trusses may be increased 25 per cent when wind and temperature stresses are included, provided the required section is not thereby reduced. Accordingly, the maximum total unit stress in the stiffening truss (for contingent future maximum loading) is 30,000 lb. per sq.in. This leaves a safety margin of 6,000 lb. per sq.in. below the minimum elastic limit of the steel used.

Some Special Details—The continuity of the stiffening truss and its support against reversible vertical and lateral reactions on the rocking towers and cable-bents gave rise to special problems in devising efficient bearing connections; these connections had to take care of the reversible reactions while permitting the necessary relative longitudinal movements due to combined span expansion and tower rocking. The connection detail adopted consisted of sliding pins, rotating in annular bushings in one of the members to be connected and sliding between bronze bearings in the other member.

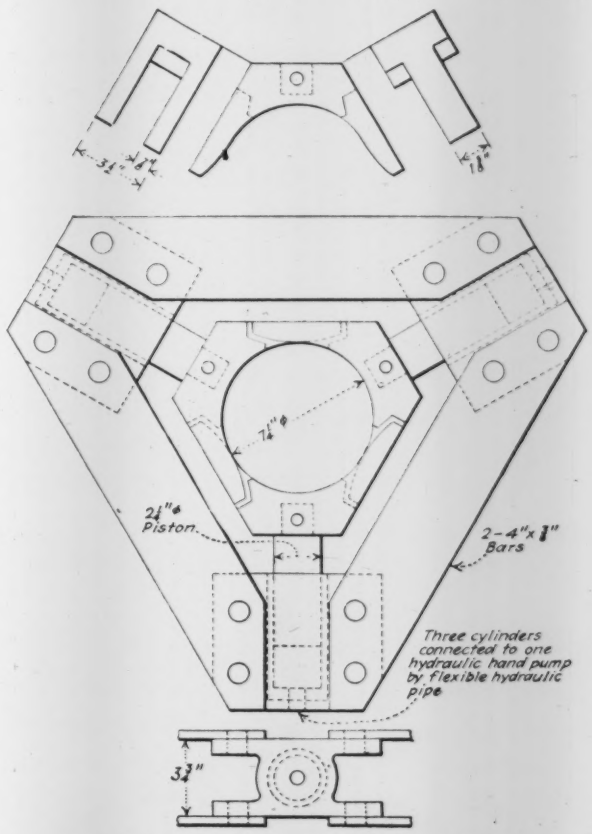


FIG. 6—THREE-PLUNGER CABLE SQUEEZER
Actuated by hand-operated hydraulic pump

For the connection of the truss to the towers, the pins turn in the truss gusset and slide in a casting attached to the tower girder. Each pin is 6 in. square for a length of 11 in., to slide between top and bottom phosphor bronze bushings in a rectangular slot in a steel casting bolted to the reaction girder of the tower; the ends of the pin are turned to 6-in. diameter, to turn in phosphor bronze annular bushings set in annealed steel castings bolted to the projecting truss gussets at L_{20}. The effective length of the slot is 14½ in., providing amply for combined truss expansion and tower movement.

To take care of the lateral wind reaction at the main tower, a thrust bracket is built up from the tower cross-girder, to engage the faces of two built-up brackets on the underside of the floorbeam. The central thrust bracket has its two bearing sides faced with 1-in. steel plates, planed to smooth finish; the two engaging thrust brackets have their bearing ends faced with 2-in. steel

plates, planed to convex cylindrical surface. This detail permits relative longitudinal movement of truss and tower, while providing effective line-bearing for taking the lateral wind reactions from the continuous bottom lateral truss system into the main towers.

The cable bands are of novel design, developed for ease of fabrication and economy. While the upper or suspender-saddle portion is an annealed steel casting, the lower half is a steel plate, 10x⅜x11 in., hot-pressed to the desired contour; this pressed steel plate is less expensive than the usual casting detail. Two 1½-in. U-bolts, going around under this curved plate, pass up through the cast cable band top. The suspender groove in the top casting is flared at the sides, to permit all the cable band castings to be built with a single pattern. Small keeper plates, 2x⅜ in., are tap-bolted over the side suspender grooves, after the rope is in place, as a safeguard against accidental displacement of the suspender.

Departing from conventional practice, the stringers are spliced together with top tie-plates over the floorbeams. The resulting effect of partial continuity increases the efficiency of the stringers and relieves the connection of certain objectionable secondary stresses.

A wire fencing design was adopted for the railings of the Portsmouth bridge. Top and bottom rails of 2½-in. galvanized pipe, spaced 37 in., are U-bolted (with spacing blocks) to the truss posts and diagonals; between these pipe rails are mounted panels of woven fabric of No. 6 galvanized wire, 2-in. mesh; these panels are two per truss panel, and are framed with 1½-in. galvanized channels for stiffening and attachment. This design, while comparatively light and inexpensive, has an advantage of superior resilience in comparison with conventional bridge railings.

Construction of the Cables—The cables of the Portsmouth bridge were not constructed by the conventional method of stringing-in-the-air with the aid of temporary footbridges, but by stringing the individual strands on the ground. Complete sets of erection drawings were prepared for the two methods of cable construction; the contractor selected the ground-stringing method. Since, for small cables, the footbridge method involves a high plant cost per pound of cable material, the ground-stringing method may be more economical under favorable conditions. But the principal advantage offered by the ground-stringing method is the possibility of constructing the cable strands before the towers and anchorages are completed, thereby saving time in the completion of the bridge. At Portsmouth, the cable strands were completed on the ground before the steel towers were ready to receive them.

The method of ground-stringing, revived for the Portsmouth bridge, was the prevailing practice for the Ohio River bridges built by Laub and his school about a generation ago; whence it is sometimes called "the Ohio River method." One objection to it is the lack of conformation of the strand, as built, to the curvature over the saddles; this tends to produce an excess of tension in the upper wires of the strand. To meet this objection, the writer's firm introduced into the strand-stringing plan means for producing pre-calculated initial bends or curvature in the strand corresponding to the computed difference of length between the top and bottom wires; for this purpose, the strands during stringing were inclined downwards for a distance near each end to the temporary anchorages of the strand shoes.

For the stringing of the strands, an existing railroad siding on the Kentucky shore was extended to provide the necessary length of 1,800 ft. A gasoline track-car was used, running back and forth on this track, to lay the wires in a sheet-metal lined V-trough on either side. The track-car carried the 26-in. coils of wire on swifts, which were controlled when necessary by hand-operated brakes; thence inclined guides guided the wire to the troughs. Below the level of the track, at either end of the 1,800-ft. length, an anchorage of concrete and steel rails was provided to hold the strand shoes at pre-calculated elevation, inclination and distance. The individual wires were stretched, in adjustment around the strand shoes, to a spring-balance pull pre-calculated for varying temperatures. Two strands (486 wires each) were strung simultaneously; temporary wire seizings were placed at short intervals around each completed strand. When the two strands were completed, they

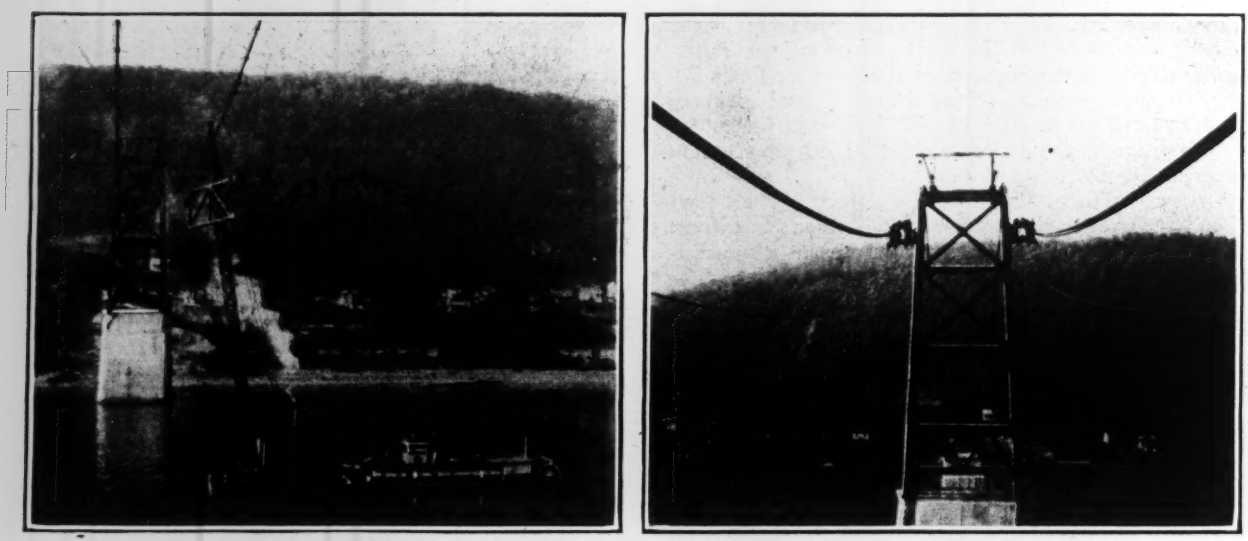


FIG. 7—ERECTION OF SUPERSTRUCTURE OF PORTSMOUTH BRIDGE
Hanging first section of stiffening truss in main span. Squeezing cables in Ohio side span

were shifted to one side along the track; and the operation was repeated for the second and third pairs of strands.

After the six strands were completed, and the towers were ready to receive them, they were taken individually across the river and raised to position. Each strand was guided around a quarter-turn to the shore, and pulled across the river on barges; the strand shoes at the two ends were secured to their permanent anchorages, and the strands were then hoisted up to their position in the tower saddles by means of lines from gallows frames mounted on the tower tops.

The use of footbridges was completely dispensed with. Erection cages suspended from trolleys running on the cables were employed for the operations of squeezing the cables and placing the cable bands and suspenders.

Spiraling of Strand—In the ground-stringing of the strands a mishap occurred which was temporarily upsetting but which was corrected without serious consequences. When the ground-stringing of the first pair of strands was completed, one of these strands was released from its temporary anchorage at one end by prying the strand shoe from its fastening; immediately upon this sudden release of tension, the end of the strand, for a length of about 50 ft., sprang into a spiral coil, the attached strand shoe turning over and over on the ground with the twisting of the strand. Somehow, it appears, the wires had worked around in the strand into a condition where their individual tendencies to coil produced a similar summation effect for their aggregate.

For the moment it appeared that the strand would have to be given up as lost. Various measures were considered, including salvaging the wire by unstringing the first pair of strands, and mechanically or heat-straightening all wire before continuing with the ground-stringing procedure. It was finally decided to make an attempt to unspiral the coiled strand, and this was successfully accomplished with far less difficulty than was anticipated and without any injury to wires or strand. With a few precautions, including the use of a snub-line to keep the strand under tension and the use of a "monkey-tail" to keep the strand-shoe from turning over, it was found possible to handle the strands without a recurrence of the spiraling. The remaining four strands were strung in the same manner as the first pair, without resorting to the use of straightened wire; and all six strands were subsequently erected without loss or too serious trouble in handling in spite of their lively nature.

Thus the mishap fortunately had no serious consequences. The writer has since learned that similar curling up of strands occurred during the cable stringing for one of the Ohio River bridges of a generation ago, and that in that instance one or two strands actually had to be given up as a complete loss. Had that incident been reported in the published accounts, the near-recurrence at Portsmouth could have been anticipated and avoided.

The safest precaution in the future, when the ground-stringing method is adopted, is to use wire that is either mechanically or heat-straightened so that all tendency to coil may be avoided. Unstraightened wire was purchased for the Portsmouth bridge before the substitution of ground-stringing for air-stringing was contemplated.

The stiffening trusses were shop-riveted and shipped in units of two panels each. These units were raised from the barges by means of a derrick boat, and were connected directly to the suspenders ready to receive them. When all of the truss units were thus suspended, they were pinned and bolted together, ready for final field riveting. This method of truss erection proved rapid and cheap. The entire stiffening trusses and floor system were erected in a little more than two weeks.

To facilitate the field connections between the truss units, the gusset plate on the inside of the truss was shop-riveted to one truss unit, and the gusset plate on the outside of the truss was shop-riveted to the other truss unit. The top and bottom splice plates were similarly handled. In this manner, the necessity of entering connections was avoided.

Organization—The substructure of the Portsmouth bridge was constructed and the superstructure was fabri-

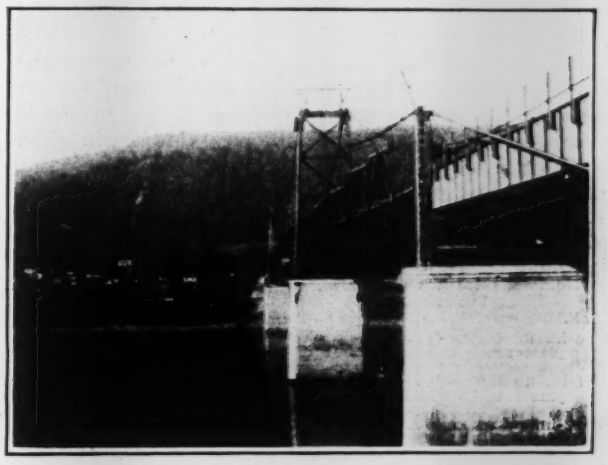


FIG. 8—SIDE-SPAN TRUSSES IN PLACE, BEFORE JOINING

cated and erected by the Dravo Contracting Co. The writer's firm, Robinson & Steinman, who had prepared the winning design for this bridge, was also retained by the contractors as consulting engineers during construction. The J. E. Greiner Co. was retained from the start as consulting engineers by the owners, the Portsmouth-Fullerton Bridge Co. In order to avoid duplication of effort and overlapping of responsibility, it was arranged that Robinson & Steinman should be responsible for the design and details of the suspension bridge including the anchorages, and that the J. E. Greiner Co. should be responsible for the design and details of the substructure and the viaduct approaches.

Study of Behavior of Rivers in Great Basin

In western United States there is a drainage area, known as the Great Basin, in which the rivers all flow to a number of inland lakes that have no outlet and from which the surplus water disappears by evaporation. The U. S. Geological Survey has made daily measurements of the principal streams in this region for many years and has published these records in annual volumes. In Water Supply Paper 570, just issued, is found 180 pp. of statistical information showing the behavior of the rivers in the Great Basin for the year ending Sept. 30, 1923 (25c. from the Superintendent of Documents, Washington, D. C.). The Great Basin consists of nearly all of Nevada, a considerable portion of Utah, and parts of Wyoming, Idaho, Oregon, and California.

Fire Resistance of Brick Walls Under Working Load

EXTENDED fire tests of brick walls carried out during several years at the Bureau of Standards, Washington, have been completed with results summarized in the table below, as given in the bureau's August *Technical News Bulletin*. The test panels were up to 16 ft. wide and 10 to 11 ft. high, and were applied to the side of a furnace permitting the production and maintenance of temperatures according to the American Standard fire test. The panels could be loaded during the test by testing-machine pressure applied to steel frames inclosing the panels; by this means loads of 80 lb. per sq.in. for 4-in. walls and 160 lb. per sq.in. for thicker walls were maintained during the test.

The fire-resistance periods given in the table represent the length of time required to attain an average temperature of 250 deg. F. (139 deg. C.) on the unexposed side, or else the time required for failure under working load; load failure occurred first only in the case of 12-in. unplastered walls built of bricks having low fusion point, while in all other walls the temperature transmission determined the period. The plaster, where applied, was of gypsum or cement with three volumes of sand. In the walls marked "solid," bricks were laid flatwise in common bond with one header course for every five stretcher courses. In the hollow walls marked "rolok," the bricks were set up on edge with alternate headers and stretchers, or with two rows of stretchers on edge alternating witih a row of headers laid flatwise. In the hollow walls marked "rolokbak," bricks on one face of the wall were laid flat and for the rest of the wall on edge, one header course alternating with six stretcher courses in the face and four in the backing. The mortar in which the walls were laid was 1:3 cement or cement-lime mortar.

Joists or other combustible members framed into the wall (to a depth of 4 in.) were found to reduce the fire-resistance period, as shown.

As the figures given in the table are ultimate values, the Bureau recommends that a factor of safety of 1½ will not give a greater margin than necessary. In other words, if the service condition of a building is such that a wall should be able to resist six hours of fire condition, a wall giving a 9-hour fire-resistance period should be used.

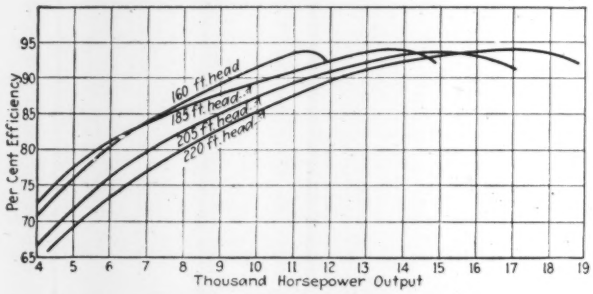
ULTIMATE FIRE-RESISTANCE OF BRICK WALLS

Nominal thickness	Building members projecting into wall	Fire Resistance Period
Solid Walls		*Hours*
4-in. unplastered	None or incombustible	1
plastered both sides.	None or incombustible	2½
	None or incombustible	5
8-in. unplastered	Combustible	2
plastered both sides.	None or incombustible	9
	Combustible	4
12-in. unplastered	None or incombustible	10 (load)
		13 (temp.)
	Combustible	9
Hollow Walls		
8-in. "Rolok" construction unplastered	None or incombustible	2½
	Combustible; hollow spaces at floor line filled	2
8-in. "Rolok," plastered both sides	None or incombustible	5
	Combustible; hollow spaces at floor line filled	4
	Combustible (from one side only); hollow spaces at floor line not filled	2½
12-in. "Rolok," unplastered	None or incombustible	5
	Combustible; hollow spaces at floor lines filled	5
	Combustible (from one side only); hollow spaces at floor line not filled	3½
12-in. "Rolok," plastered both sides	None or incombustible	9
	Combustible; hollow spaces at floor line filled	9
	Combustible, (from one side only); hollow spaces at floor line not filled	6
8-in. "Rolokbak" construction, brick-faced, plastered back side	None or incombustible	5
	Combustible; hollow spaces at floor line filled	9
	Combustible; hollow spaces at floor lines not filled	2½
12-in. "Rolokbak," unplastered	None or incombustible	10
	Combustible; hollow spaces at floor lines filled	9
	Combustible; hollow spaces at floor lines not filled	6

Turbine Efficiency 94 Per Cent Over Wide Range of Head

TWO hydraulic turbines recently installed in the Melones power house on the Stanislaus River in California have attained an efficiency of approximately 94 per cent at heads ranging from 160 to 220 ft. These efficiencies were shown in tests made by the salt velocity method under the direction of Edward A. Taylor, representing Prof. C. M. Allen.

At the Melones plant power is generated with water stored partly for irrigation purposes, the water passing through the power house on its way to irrigation ditches. Specifications for the turbines were prepared by the engineering department of the Pacific Gas & Electric Co. with a view to adapting the installation to the use of stored water to supply irrigation needs. To serve these needs the head on the plant has to vary from 122 ft. to 228 ft. although 75 per cent of the annual output would be generated at heads exceeding 175 ft. Contract for the turbines was awarded to the S. Morgan Smith Co. under a guarantee of 91 per cent at 200-ft. head and including a provision for 85 per cent efficiency at 125-ft. head.



EFFICIENCIES OF TURBINES IN THE MELONES PLANT

The turbines are single-runner, vertical, Francis type, 17,000-hp. units. Each runner is a single piece of annealed cast steel. The intake of the spiral plate steel casings is 7½ ft. in diameter and the discharge is into concrete draft tubes lined with plate steel. The accompanying chart shows the efficiency curve on one of the units at four heads ranging from 160 to 220 ft. with output correspondingly varying from 11,000 hp. to 17,750 hp.

Steel Penstock Design by a Graphical Method

Charts Used to Determine Proper Thickness of Steel Plates, Most Efficient Type of Joint—Weight and Cost of Pipe—Both Riveted and Welded Pipe Included, also Various Working Stresses

By Peter Bier
Engineer, U. S. Bureau of Reclamation, Denver, Colo.

VARIOUS methods have been proposed for the economic design of penstocks. Among these the one described by H. L. Doolittle in the 1924 Mid-November edition of *Mechanical Engineering* seems, in the writer's opinion, to be one of the most efficient. However, the computations and cost estimates required in connection with that method consume much time. A graphical method is proposed herewith to simplify the work and to assist the engineer in the selection of the proper thickness of steel plate, the design of the most efficient joint, and in the estimate of the correct weight and cost.

The method of selecting plate thickness of riveted and welded pipe for a given head and diameter and for a range of longitudinal joint efficiencies from 40 to 100 per cent is shown in Charts 1 and 1-A. The safe working stresses used in preparing the figures were from 10,000 to 15,000 lb. per sq.in. The total head noted is the static head plus an excess head due to water-hammer. It is considered good practice to calculate the excess head or pressure rise which is produced during a total shutdown due to normal governor action on the gates. If the calculated pressure rise is found to be excessive, as in the case of very long penstocks or high velocities, the turbines should be provided with synchronous bypasses or relief valves. These will prevent a pressure rise above a certain percentage of the static head. Thus the proportion of excess head to be added to the static head may readily be determined and the pipe plate thickness selected for the total head.

An example will best illustrate the proper use of the accompanying figures and tables.

Suppose it is necessary in an analysis to find the relative weights and costs of several 51-in.-diam. steel pipes of different joint construction. Select double butt-riveted, triple butt-riveted, and welded pipe, all under a total head of say 800 ft. First locate the line representing the 800-ft. head on the vertical scale of Chart 1. Project this line horizontally to the point of intersection with the diagonal *B* representing the 51-in. diameter, as indicated in Chart 2. Then project from this point vertically up to the working stress desired. If a 12,000-lb. stress is desired, for instance, the vertical line will be projected up to line *C*, representing that stress, thence along the diagonal lines to *D*, which stands for 100 per cent efficiency. Vertically above *D* at the efficiency value determined from Tables I to V is a point within the sector representing the required plate thickness. For the double butt-riveted pipe it is found from Table II, that the efficiencies for the various plates average about 80 per cent. Locate this approximate efficiency on the chart and select the corresponding plate thickness, which in this case will be $\frac{13}{16}$ in. Checking back

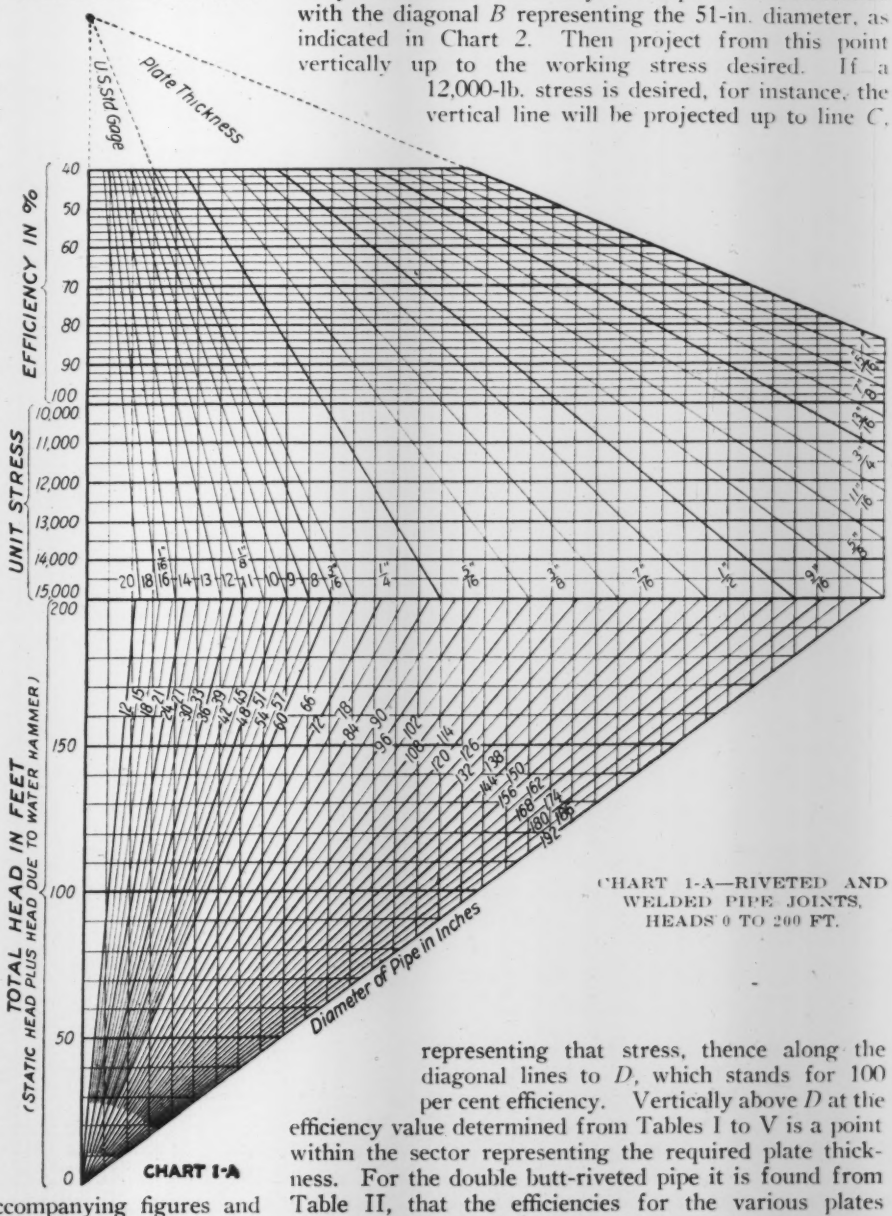


CHART 1-A—RIVETED AND WELDED PIPE JOINTS, HEADS 0 TO 200 FT.

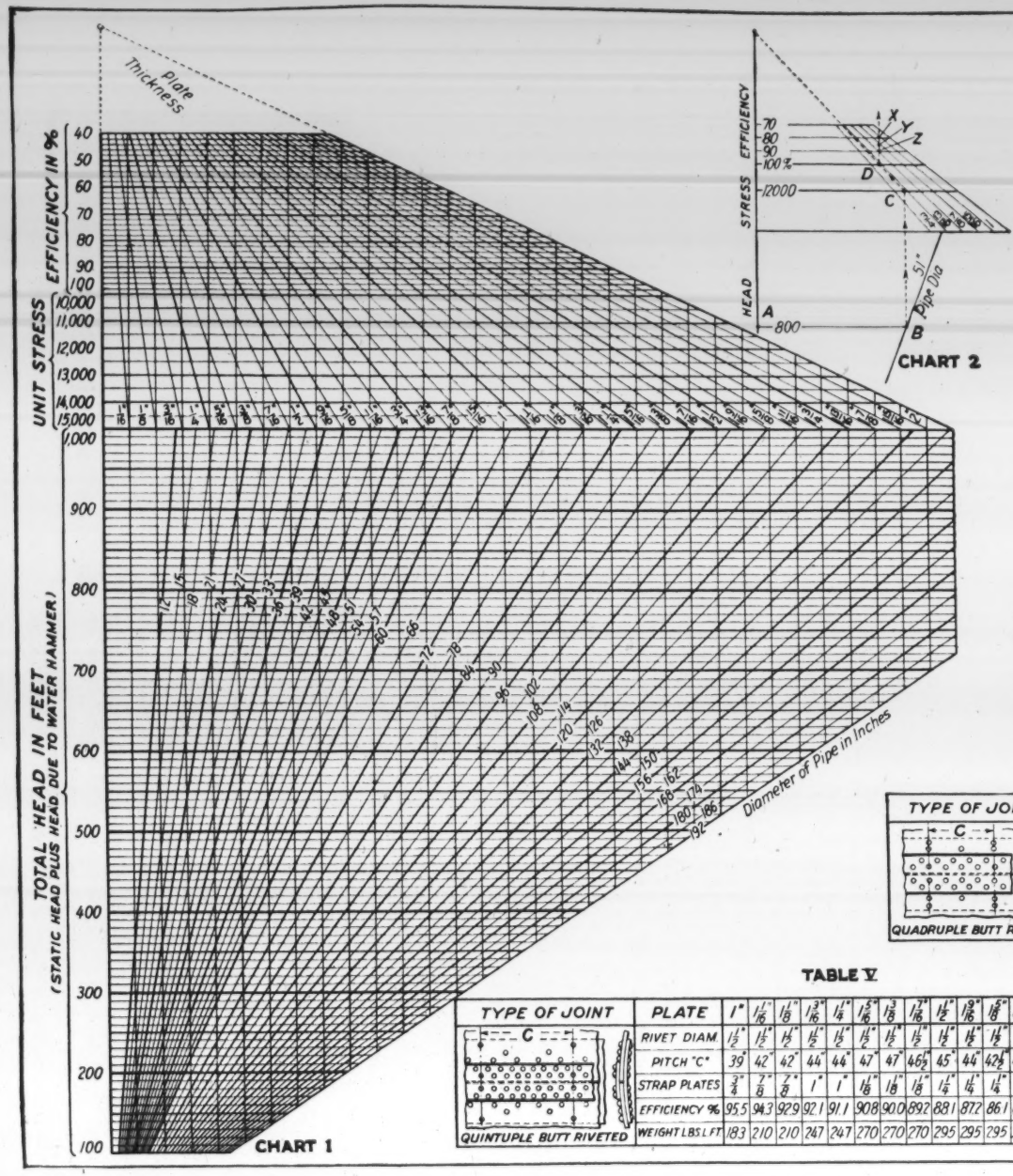


TABLE I JOINT DATA

TYPE OF JOINT	PLATE	1/8"	3/16"	1/4"	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"	11/16"	3/4"
SINGLE LAP RIVETED	RIVET DIAM.	3/8"	1/2"	5/8"	3/4"	7/8"	1"	1 1/8"	1 1/4"			
	PITCH "C"	1 5/16"	1 3/4"	2"	2 1/4"	2 5/8"	2 5/8"	3"	3 3/8"	3 3/4"		
	EFFICIENCY %	57.3	55.6	59.3	58.3	55.5	48.0	47.2	46.7	46.2		
	WEIGHT LBS. L.F.	1	2	3	5	6	7	9	11	14		
DOUBLE LAP RIVETED	RIVET DIAM.	3/8"	1/2"	5/8"	3/4"	3/4"	7/8"	1"	1 1/8"	1 1/4"	1 1/4"	1 1/4"
	PITCH "C"	2 1/16"	2 1/2"	2 13/16"	3 1/16"	3 1/8"	3 1/16"	3 13/16"	4 1/16"	4"	4 1/2"	4 3/16"
	EFFICIENCY %	72.8	72.6	71.1	69.5	70.0	72.5	72.2	70.7	70.3	69.7	68.7
	WEIGHT LBS. L.F.	2	3	5	7	8	11	14	18	20	25	27

TABLE II

TYPE OF JOINT	PLATE	3/8"	7/16"	1/2"	9/16"	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"
DOUBLE BUTT RIVETED	RIVET DIAM.	3/4"	7/8"	1"	1 1/8"	1 1/4"	1 1/4"	1 1/4"	1 1/4"	1 1/4"	1 1/4"	1 1/4"
	PITCH "C"	4 3/4"	5 5/16"	6"	6 7/8"	7 5/8"	7 7/16"	7 1/4"	7 3/8"	7 1/8"	7 1/8"	7"
	STRAP PLATES	5/16"	3/8"	7/16"	1/2"	1/2"	9/16"	9/16"	5/8"	5/8"	3/4"	3/4"
	EFFICIENCY %	82.4	82.8	82.6	82.5	82.6	82.1	81.9	81.6	80.5	79.0	77.4
	WEIGHT LBS. L.F.	22	30	39	49	58	63	64	70	70	82	82

TABLE III

TYPE OF JOINT	PLATE	3/8"	7/16"	1/2"	9/16"	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"	1 1/16"	1 1/8"	1 3/16"	1 1/4"
TRIPLE BUTT RIVETED	RIVET DIAM.	5/8"	5/8"	3/4"	7/8"	7/8"	1"	1 1/8"	1 1/4"	1 1/4"	1 1/4"	1 1/4"	1 1/4"	1 1/4"	1 1/4"	1 1/4"
	PITCH "C"	6"	6 1/8"	6 7/8"	7 3/8"	7 3/8"	8"	8 1/8"	8 3/8"	8 3/4"	9 1/8"	9 3/8"	9 5/8"	10"	10"	10"	9 1/2"
	STRAP PLATES	5/16"	3/8"	7/16"	1/2"	1/2"	9/16"	9/16"	5/8"	5/8"	3/4"	3/4"	7/8"	7/8"	1"	1"
	EFFICIENCY %	88.5	88.5	88.4	87.2	86.4	86.5	85.5	85.0	84.0	84.5	83.6	84.0	83.5	82.2	81.6
	WEIGHT LBS. L.F.	25	30	42	54	54	68	79	102	102	117	117	131	131	149	151

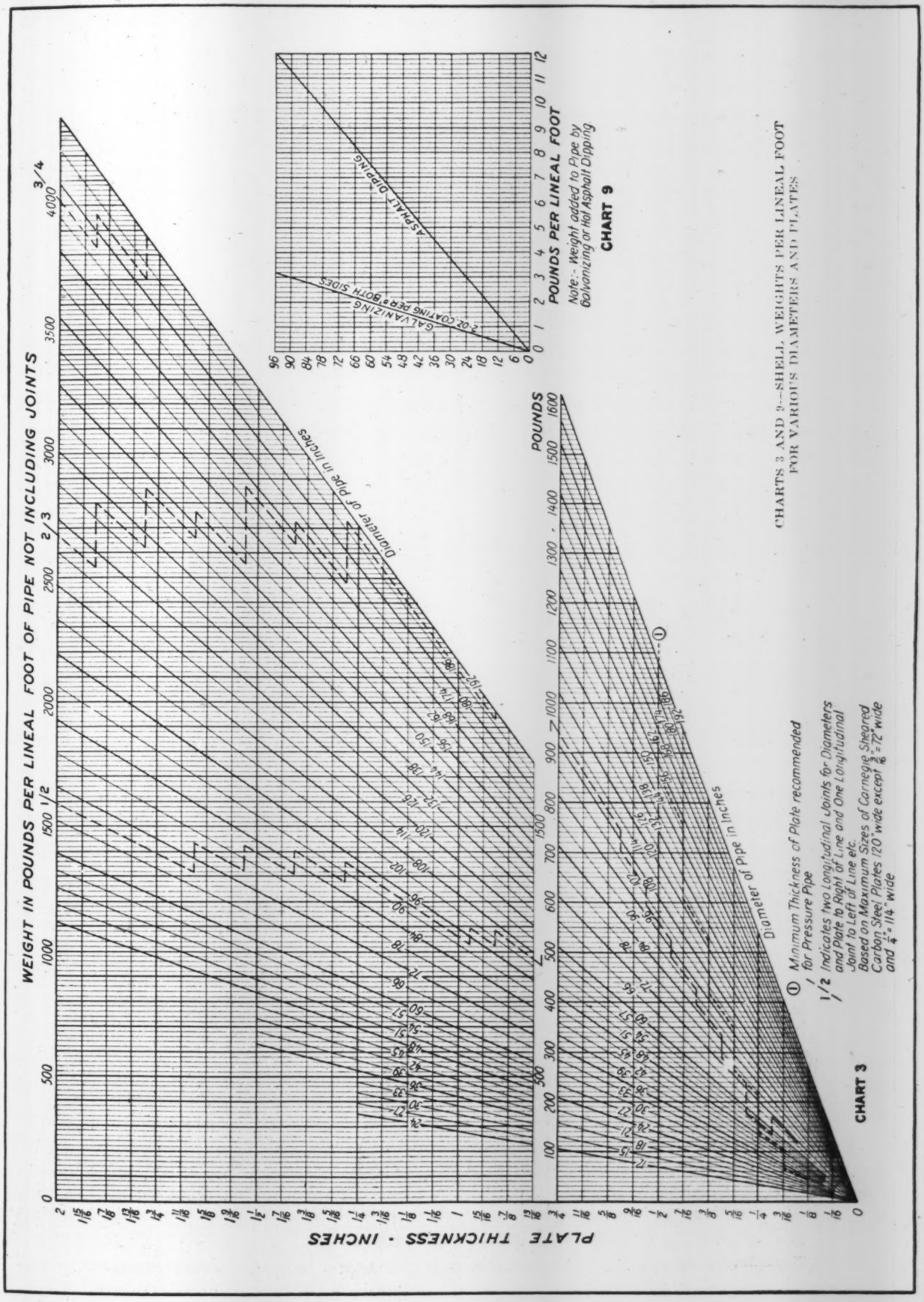
TABLE IV

TYPE OF JOINT	PLATE	3/8"	7/16"	1/2"	9/16"	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"	1 1/16"	1 1/8"	1 3/16"	1 1/4"	1 5/16"	1 3/8"	1 7/16"	1 1/2"
QUADRUPLE BUTT RIVETED	RIVET DIAM.	5/8"	3/4"	3/4"	7/8"	7/8"	1"	1 1/8"	1 1/8"	1 1/8"	1 1/8"	1 1/8"	1 1/8"	1 1/8"	1 1/8"	1 1/8"	1 1/8"	1 1/8"	1 1/8"	1 1/8"
	PITCH "C"	12"	13"	13 1/2"	14 1/4"	14 3/8"	16"	16 1/4"	17"	17 1/2"	18 3/8"	18 3/8"	20"	20"	20"	19 1/4"	21 1/2"	21"	20 1/4"	19 1/2"
	STRAP PLATES	5/16"	3/8"	7/16"	1/2"	1/2"	9/16"	9/16"	5/8"	5/8"	3/4"	3/4"	7/8"	7/8"	1"	1"	1 1/8"	1 1/8"	1 1/8"	1 1/4"
	EFFICIENCY %	93.6	93.6	93.8	93.6	92.5	92.7	92.5	91.3	91.2	90.4	89.4	89.0	88.0	86.6	85.4	87.1	85.5	84.9	83.8
	WEIGHT LBS. L.F.	30	43	49	64	64	80	95	103	121	139	139	156	156	178	179	217	217	217	240

TABLE V.

TYPE OF JOINT	PLATE	1"	1 1/16"	1 1/8"	1 3/16"	1 1/4"	1 5/16"	1 3/8"	1 7/16"	1 1/2"	1 9/16"	1 5/8"	1 11/16"	1 3/4"	1 13/16"	1 7/8"	1 15/16"	2
QUINTUPLE BUTT RIVETED	RIVET DIAM.	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"
	PITCH "C"	39"	42"	42"	44"	44"	47"	47"	46 1/2"	45"	44"	42 1/2"	41 1/2"	40 1/2"	39 1/2"	38 1/2"	38"	37"
	STRAP PLATES	3/4"	7/8"	7/8"	1"	1"	1 1/8"	1 1/8"	1 1/8"	1 1/4"	1 1/4"	1 1/4"	1 1/8"	1 1/8"	1 1/8"	1 1/2"	1 1/2"	1 1/2"
	EFFICIENCY %	95.5	94.3	92.9	92.1	91.1	90.8	90.0	89.2	88.1	87.2	86.1	85.2	84.3	83.4	82.5	81.7	80.8
	WEIGHT LBS. L.F.	183	210	210	247	247	270	270	270	295	295	295	320	315	315	340	340	340

CHART 1 AND TABLES I TO V.—RIVETED AND WELDED PIPE JOINTS, HEADS 100 TO 1,000 FT.


WEIGHT IN POUNDS PER LINEAL FOOT OF PIPE NOT INCLUDING JOINTS
PLATE THICKNESS · INCHES
Diameter of Pipe in Inches
POUNDS
GALVANIZING 2 OZ. COATING PER ft² BOTH SIDES
ASPHALT DIPPING
POUNDS PER LINEAL FOOT
Note:- Weight added to Pipe by Galvanizing or Hot Asphalt Dipping
CHART 9
CHART 3
① Minimum Thickness of Plate recommended for Pressure Pipe
1/2 Indicates two Longitudinal Joints for Diameters and Plate to Right of Line and One Longitudinal Joint to Left of Line etc.
Based on Maximum Sizes of Carnegie Sheared Carbon Steel Plates 120" wide except 3/16" = 72" wide and 1/4" = 114" wide

CHARTS 3 AND 9—SHELL WEIGHTS PER LINEAL FOOT FOR VARIOUS DIAMETERS AND PLATES

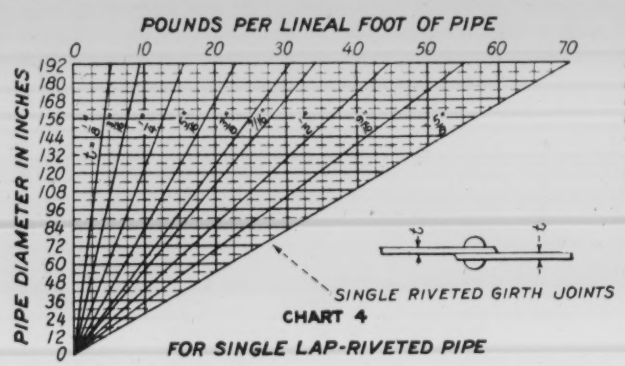


CHART 4

FOR SINGLE LAP-RIVETED PIPE

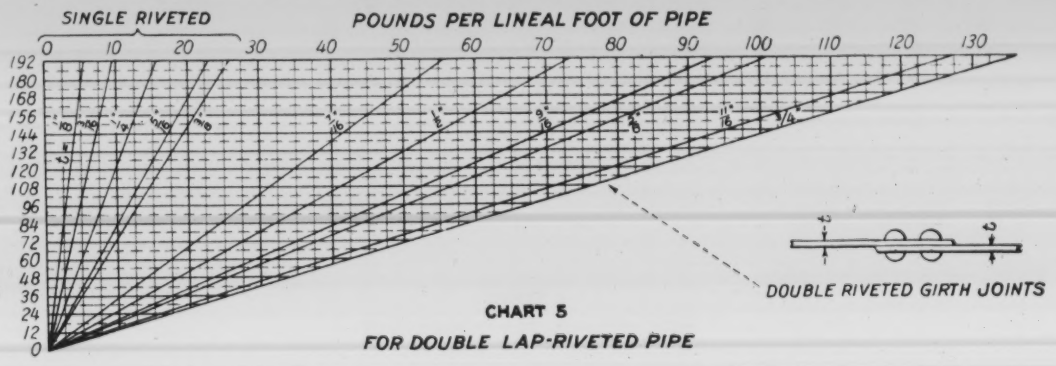


CHART 5

FOR DOUBLE LAP-RIVETED PIPE

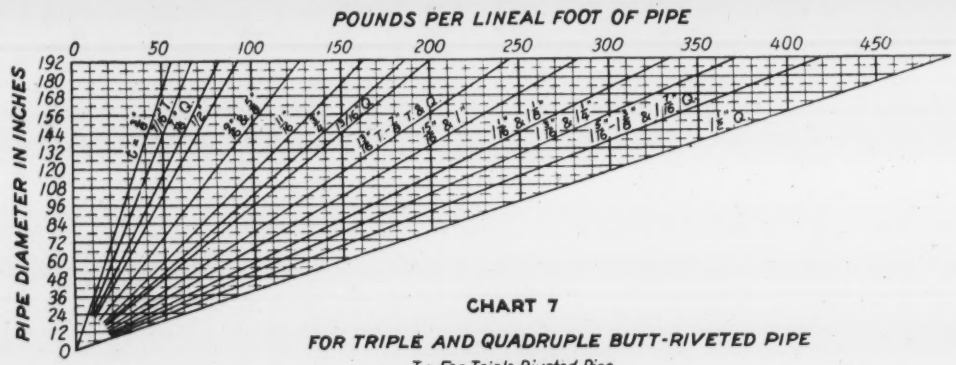


CHART 7

FOR TRIPLE AND QUADRUPLE BUTT-RIVETED PIPE

T = For Triple Riveted Pipe
Q = For Quadruple Riveted Pipe

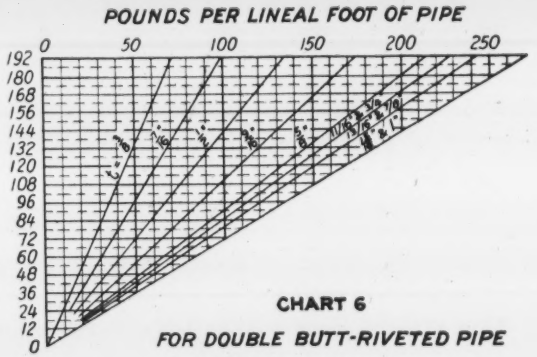


CHART 6

FOR DOUBLE BUTT-RIVETED PIPE

DOUBLE RIVETED GIRTH JOINTS
(Single Outside Strap)

Note: This type of Joint for Double, Triple, Quadruple and Quintuple Butt-riveted Pipe.

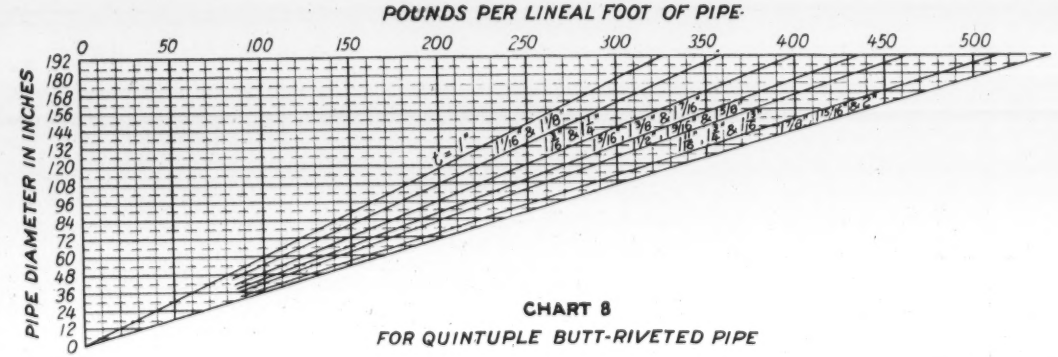


CHART 8

FOR QUINTUPLE BUTT-RIVETED PIPE

CHARTS 4 TO 8—GIRTH JOINT WEIGHTS PER LINEAL FOOT

with this plate thickness for the exact joint efficiency in Table II it is noted as 79 per cent. The above-described procedure is repeated with this efficiency and found to check the $\frac{1}{16}$-in. plate thickness selected at first.

For the triple-riveted butt-joint, Table III gives an efficiency for the probable plate thickness of about 84 per cent. With the 12,000-lb. stress used above, this pipe will require a $\frac{7}{8}$-in. plate, which has an actual efficiency of 84 per cent as used above.

The welded pipe, with a joint efficiency assumed at 90 per cent for all thicknesses, requires also a $\frac{7}{8}$-in. plate, if the 12,000-lb. stress is not to be exceeded. It would take a quadruple-riveted joint to reduce the plate thickness to $\frac{1}{16}$ in.

The efficiencies given in the tables are based on the rivet diameters and pitches noted therein, also on sub-punched and reamed holes for plates over $\frac{3}{8}$ in. thick when lap-riveted, and for plates over $\frac{5}{16}$ in. thick when butt-riveted.

Chart Values—The values in Charts 1 and 1-A are calculated from the formula

$$t = \frac{r \times p}{S \times E} = \frac{r \times h \times .4335}{S \times E} \text{ or } h = \frac{t \times S \times E}{r \times .4335}$$

where

t = plate thickness in inches,
r = radius of pipe in inches,
p = internal pressure in pounds per square inch,
h = head in feet,
S = safe working stress in plate, in lb. per sq. in.,
E = efficiency of longitudinal joint, in per cent.

The weight per lineal foot of pipe for the various types of joint may be taken from Charts 3 to 8 inclusive and from Tables I to V.

Chart 3 gives the weight of the pipe shell only. Tables I to V give the weight of the longitudinal joints for lap- and butt-riveted pipe. Charts 4 to 8 give the weight of the girth joints for lap- and butt-riveted pipe.

Before the weight of the longitudinal joints can be selected from the tables, it is necessary to determine the number of plates or longitudinal joints to be used in the fabrication of the pipe. This, for pipes which are to be riveted in the shop, will depend mostly on the size of the steel plates which can be obtained from the mill or are available in local stock. For field riveted pipe, shipped knocked down, the number of longitudinal joints depends mainly on shipping considerations. The irregular zigzag lines running through Chart 3 indicate the maximum diameters which can be formed with one, two and three plates or longitudinal joints for the corresponding plate thickness. This is based on the maximum lengths of Carnegie sheared carbon steel plates of 120-in. width, excepting $\frac{1}{8}$-in. and $\frac{3}{16}$-in. plates which are based on a 72-in. width and $\frac{1}{4}$-in. plates which are based on a 114-in. width. These plate widths will also determine the spacing of the girth joints and their weight per lineal foot of pipe. If different plate widths are used than those specified above, a proportional quantity should be added to the weight of the girth joints given. For instance, the weight of the girth joints for a pipe with $\frac{3}{8}$- x 96-in. plates or a joint spacing of 8 ft. 0 in. is obtained by multiplying the chart value by 10/8.

The girth joints provided for in the standard specifications of the National Electric Light Association are usually of sufficient strength for the requirements of the average penstock. There are cases, however, where due to the magnitude of the longitudinal forces in the pipe line this girth joint is inadequate and one with a higher efficiency will have to be provided for. This can be determined only by an analysis of the whole pipe line, the spacing of the anchors and expansion joints and the distance between supporting piers being the influencing factors. The girth joints will have to withstand safely the stresses due to temperature changes in the pipe line, and due to the Poisson contraction, as well as those stresses which are caused by the beam action of the pipe between supports. The weights of the girth joints as given in the charts should be increased if the longitudinal stresses in the pipe necessitate a heavier and more efficient joint.

Other factors which might increase the weight of the pipe beyond the requirements of the head are the minimum allowable thickness for corrosion, rigidity during construction, etc., and the use of stiffening rings. For large diameter pipes with thin plates it is often necessary to rivet stiffening angles on the outside to avoid collapse and a consequent opening of the calked joints of the pipe. A discussion of this subject with a table giving pipes requiring stiffening and their calculation is included in the recently published "Hydro-Electric Handbook" by Creager and Justin.

With the 51-in.-diam. pipe and the plate thicknesses for the various joints selected above, the weights per lineal foot of finished pipe may be obtained. Using the 120-in. plate widths specified, the following weights are obtained.

For the double butt-riveted pipe with $\frac{1}{16}$-in. plate and one longitudinal joint (as for shop riveted pipe):

	Lb.
Weight of the shell (Chart 3)	553
Weight of longitudinal joint (Table II)	82
Weight of the girth-joints (Chart 6)	72
Total weight of pipe per lineal foot	707

For the triple butt-riveted pipe, with $\frac{7}{8}$-in. plate and one longitudinal joint:

	Lb.
Weight of the shell (Chart 3)	517
Weight of the longitudinal joint (Table III)	102
Weight of the girth-joints (Chart 7)	64
Total weight of pipe per lineal foot	683

For welded pipe, with $\frac{7}{8}$-in. plate, welded longitudinal joints and with double-riveted butt-girth-joints:

	Lb.
Weight of the shell (Chart 3)	517
Weight of the girth-joints (Chart 7)	64
Total weight of pipe per lineal foot	581

In Chart 9 the approximate weights due to galvanizing or hot asphalt dipping are given and may be added to the weight of the pipe.

The weights given in all charts and tables include an addition of 5 per cent to the net weight calculated. This allows for the permissible variations in the unit weight of plates. The weight of the rivet heads for riveted joints are also included.

After the unit shop cost, freight charges, handling, trucking, and the cost of erection have been estimated, the relative cost of the entire pipe line may be readily determined for any given locality.

The proper use of the charts and tables will aid in the solution of a large variety of pipe problems in a comparatively short time, and will eliminate many of the rough approximations used in estimating.

Joint Details—The joint details and efficiencies for plates up to 1¼-in. thickness were taken from the standard specifications for riveted pipe of the Pacific Coast Electrical Association. These were published in the "Report on Penstock Design" of the National Electric Light Association, Sept., 1923. The joint details and efficiencies for plates over 1¼ in. thick for quadruple-riveted pipe, and those for the quintuple-riveted joints were calculated on the same general basis and added by the writer. Modern hydro-electric practice often deals with very large units, showing the necessity for large-diameter penstocks with extremely heavy plates. This made an extension to the original tables desirable.

There are many variables which enter into the design of riveted steel pipe, such as the diameter and spacing of the rivets to obtain a high efficiency, the thickness of the strap plates and their width, also the number and the spacing of the joints. These variables affect the weight of the pipe in a most irregular fashion, making it rather impracticable to develop charts to give the total weight of the pipe in a single diagram.

The above data should prove equally useful in the solution of pipe problems for pumping lines and steel siphons.

Relief of Alkali Troubles on Irrigated Land Being Sought

Drainage and Leaching Not Sufficient—Special Crops, Chemicals and Soil Management May Remedy Bad Conditions

DEVELOPMENTS in the reclamation of alkali lands, or lands spoiled for agricultural purposes by the accumulation of alkaline salts at the surface, are still in an inconclusive state, but the problem is being studied by means of field and laboratory experiments now being conducted by the federal government and by several western state colleges. This, in brief, is the situation as outlined at the annual meeting of the American Society of Agricultural Engineers by James C. Marr, associate irrigation engineer of the U. S. Department of Agriculture, stationed at Boise, Idaho. An abstract of his general review is given below, but omits the particulars of individual experiments.

Attention has been focused on alkali land in this country chiefly because of the tendency for this condition to appear and work a hardship in our irrigated sections. The experience has usually been that, unless some means of drainage is provided at the proper time, the land becomes waterlogged. This condition causes a concentration of alkali at or near the ground surface, which results in the gradual conversion of highly improved land into barren wastes. This situation has called for: (1) Prevention of further damage by prompt and efficient drainage; and (2) reclamation of damaged areas. The latter requires that the soil be drained, that excess salt be removed from the soil, and that physical damage to the soil be repaired. Drainage as a preventive measure is now being accomplished with fair success and has largely put a stop to the damage. But there still remain unsolved problems in connection with the reclamation of lands already damaged.

Ten years ago it was commonly believed that all alkali land could be corrected by simply draining the land and then washing the accumulated salts back into the subsoil or out in the drainage water. The practice failed as often as it succeeded. The principal difficulty has been traced to the effects of sodium salts and particularly to sodium hydroxide, or black alkali. The old plan of reclamation has been found satisfactory where a material quantity of calcium in solution is present and where the soils are sufficiently porous to permit efficient leaching.

Dispersion and Impermeability—The practice would also reclaim soils containing principally sodium salts, were it not for the fact that they become dispersed and impermeable during leaching operations, which puts a stop to further reclamation. This also is the condition where soils are already dispersed and impermeable. The dispersion is caused by the presence of sodium hydroxide, which is derived from the hydrolysis of sodium carbonate and sodium zeolite. Impermeability is brought about partly by dispersion and partly by the precipitation of colloidal material in the soil mass. It is exceedingly important to note in this connection that dispersion and impermeability take place in the presence of sodium hydroxide.

Remedy in Chemical Action—Certain chemicals when applied to soils which are saturated with sodium and which are properly drained and irrigated, according to laboratory results, prevent the formation of sodium hydroxide, aid in removing the sodium, and repair physical damage to the soil which has already taken place. Calcium sulphate, calcium chloride, sulphur, iron sulphate, and other chemicals, through an exchange of bases, react with the sodium in the soil to form sodium sulphate, sodium chloride, etc., which may be carried out of the soil in the drainage water, or leached into the subsoils. Thereby also the formation of sodium carbonate and its subsequent hydrolysis, as well as the hydrolysis of sodium zeolite, is prevented and dispersion and impermeability of the soil is obviated. Furthermore, these chemicals coagulate the soil particles and thus tend to correct physical damage to the soil which may have resulted from the presence of sodium hydroxide.

Carbon Dioxide—In carbon dioxide we have another possible remedy and probably the most important one. When introduced in large enough quantity into a badly dispersed, impervious, sodium saturated soil it markedly increases permeability and largely prevents further dispersion of the soil particles by converting sodium hydroxide into sodium carbonate and this into sodium bicarbonate. Sodium bicarbonate does not hydrolyze to any great extent, consequently it does not cause dispersion and impermeability and may be leached out of the soil, thus permanently eliminating the troublesome sodium. A further reaction of carbon dioxide of even greater importance in bringing about these changes is that it will bring into solution the calcium as calcium bicarbonate, which will change the sodium zeolite into calcium zeolite. When carbon dioxide is absent, as is always the case in black alkali soils, it may be introduced through the action of soil bacteria on organic matter, which requires aeration of the soil and addition of organic matter. This may be accomplished by cultivation and by application of manure, or by cropping the land if it is possible to get anything to grow.

The knowledge that we now have of the chemical phase of the alkali problem is based largely on laboratory results. Its application to complex conditions found in nature is scarcely more than just under way, but scientific field experiments are yielding interesting results. Final solution of the problem rests on the outcome of further investigations.

Belgian Railways Under Private Operation

Reports of the status of the Belgian railways under private operation seem to indicate that the change from public to private control made last year has been a financial success. Somewhat over a year ago, the Société Nationale des Chemins de Fer Belges took over the operation of the Belgian State Rys., the government turning over to the company the rights to all railroad property, rolling stock, tools and equipment for operation as a private company, and the company began to operate in September. The results of 10 months' operation, September, 1926, to June, 1927, show a profit of 422,000,000 francs after deducting 25,000,000 francs each month since January for the constitution of a fund for the purchase of new equipment, as against 107,000,000 francs for a corresponding period the previous year.

Expansion and Contraction of Welded Gas Lines

AT THE last annual meeting of the Natural Gas Association in Tulsa, Okla., a paper prepared by F. M. Lege, Jr., vice-president and chief engineer, Magnolia Gas Co., considered the method of placing slack in a large welded pipe line to care for expansion and contraction. The paper was based on practice used on the Magnolia company's recently constructed line from Beaumont, Tex., to Shreveport, La., a distance of 215 miles. The pipe is 14, 16 and 18 in. in diameter and the line is one of the largest ever constructed. The following information is abstracted from Mr. Lege's paper.

Several methods of providing for slack in the line may be used. A sinuous line would be most satisfactory, if it were possible to hold the line sinuous until it was lowered into a straight ditch and to prevent the slack so secured from being shoved ahead of the line. However, expansion and contraction caused by differences between day and night temperatures cause the loss of practically all of the slack.

The most satisfactory method of securing and holding slack in large lines is laying the line on top of 12 to 24-in. blocks spaced 100 to 200 ft. apart. The weight of

A 20-IN. WELDED GAS LINE LAID SINUOUS TO PROVIDE FOR CHANGES IN LENGTH

the pipe between the blocks is relied upon to hold the slack so placed in the line. The line may then be lowered into the ditch during the early afternoon with skids distributed where the blocks were formerly placed. It can then be covered between the blocks and the blocks removed during the night allowing the line to settle into the ditch sufficiently to be covered. Unless the skids hold up the line at regular intervals, the slack secured by use of the blocks will crawl ahead and be lost. This will necessitate cutting the line as there will be more slack than can be placed in the ditch.

The amount of slack is of course determined by the temperature variation. Due consideration should also be given to the elasticity of the steel, and where lines cross long steep hills great care should be taken to be sure that compression exists on both sides of the hill. The use of expansion joints or couplers is unnecessary and would only be a source of trouble. Experience on many miles of both 16- and 18-in. pipe shows that with only a fairly good weld no trouble will be experienced from expansion and contraction with a temperature variation of as much as 60 deg. On the other hand, where bad rod is used or poor welding is done, the least bit of contraction will cause the weld to crack.

The manner in which a large-diameter welded gas line is placed in the ditch with regard to compression is of equal or greater importance than are good welds. A poor weld will hold under compression when it would break on a tight line.

Avalanches Compel Railway Relocation With Tunnel in Peru

A 5-MILE relocation on the Central Railway of Peru, completed in 1926, was made necessary by floods and avalanches which washed out bridges and obliterated a stretch of the original line about 45 miles from the coast. At this point the railway originally had a long loop, crossing the Rimac River at both ends and traversing the mouth of the lateral Puruhay valley. The maximum grade was 4 per cent. As stated in the *Railway Gazette*, of London, after a period of long-continued rains, with numerous slides and minor washouts, a great avalanche of rocks came down the Puruhay valley, carrying away the railway and one of the bridges, and completely filling a part of the river, so that the water finally developed a new channel around the slide.

To reopen communication, a temporary line approximating the original location but with a grade of 5 per cent, was built through the rock slide, requiring heavy blasting. This was completed in about two months, a new bridge being placed across the altered river channel. For a permanent improvement a new location was made, keeping on one side of the river so as to eliminate the bridges and the dangerous crossing of the Puruhay valley. This line was also kept above flood level and its maximum grade was 4 per cent, but it necessitated a rock tunnel 350 ft. long on a grade of 3 per cent.

As the tunnel lies near the face of the cliff, a drift 30 ft. long was driven to it, at right angles to the tunnel line. This drift was at the level of the top heading of the tunnel, so that headings could be driven in both directions from this intermediate point as well as from the portals. The compressor plant was located in ground that had been above the flood levels, but another avalanche swept over this and buried the machinery.

The new tunnel is of horseshoe section, 19.68 ft. high from floor to roof, 13.77 ft. wide at the floor and 15.74 ft. at the springing line, with an arch radius of 7.87 ft. A top heading 8x8 ft. was driven through the entire length and then widened to form the arch, after which the bench was excavated. Muck from the headings was loaded by hand into 1-yd. side-dump cars which were hauled out by compressed-air hoists. For the bench, a hoist traveling on the 24-in. track operated a dragline scraper which pulled the rock up an incline and along a trough extending behind the machine, with openings through which the rock fell into the muck cars. As a rule two blasts were fired daily. After each blast, the upper part of the face was cleared to permit placing two drills mounted on a horizontal bar. By the time these drills had finished the next set of upper holes, the scraper had cleared the muck so that the bar could be lowered for drilling the lifters and bottom holes.

Civil Engineers Consider Mississippi Floods

Fall Meeting of Society Held at Columbus—Review of Efforts to Control the Mississippi River—Commission Severely Criticized—Some Definite Proposals for Flood Relief

SELDOM has any meeting of the American Society of Civil Engineers given such serious thought or such sustained interest to one subject as was given to the problem of flood control on the Mississippi River at the fall meeting held in Columbus last week. Beginning on Wednesday afternoon with a general review of what has been done in the past to control the river, continuing into the evening when Secretary of War Davis spoke on the government's attitude, and carried on through an all-day session on Thursday in which attention was focused upon the many separate phases of the flood control work, the subject was discussed actively and received close attention of full sessions.

Despite the great interest aroused in the Mississippi River problem and the large amount of time devoted to it, other subjects were not neglected. On Thursday, the structural, sanitary engineering, and highway divisions held well attended meetings, and the subject of water supply and purification were actively discussed. At the opening technical session on Wednesday the enlargement of the city water-supply system of Columbus, through the construction of O'Shaughnessy dam, was described, and the water purification and softening plant of the city was discussed at some length; on Friday both the purification plant and the two water-supply dams of the city were visited.

Mississippi River Control—Consideration of the Mississippi flood control problem began with a symposium on flood control with special reference to Mississippi River held Wednesday afternoon. Gen. Edgar Jadwin, Chief of Engineers, U. S. Army, opened with a brief review of the present situation. Three papers followed: a resumé of the Mississippi River problem by Col. C. McD. Townsend; a paper by H. C. Frankenfield, senior meteorologist of the U. S. Weather Bureau, on rainfall characteristics of the Mississippi drainage states; and a summary by N. C. Grover, chief hydraulic engineer of the U. S. Geological Survey, of the runoff characteristics of the Mississippi drainage basin. The session was concluded by Lieut.-Col. George R. Spalding with an illustrated address upon the Mississippi flood of 1927, which gave a clear picture of the enormous work of bringing relief to the people in the vast area overflowed.

Secretary Davis was the principal speaker at the dinner on Wednesday evening. His speech had been looked to for an indication of the attitude of the government toward the Mississippi flood problem, and consequently his statement that "The plan for the future must be one complete and co-ordinated whole, carried to completion as rapidly as practicable," was received with no little surprise. Many of the engineers present were of the opinion, expressed frequently during the meeting, that the inability of the Corps of Engineers to obtain accurate information on many pertinent subjects in the short space of time at its disposal clearly indicated that no proper plan could be prepared before Congress assembles.

In commenting upon the flood problem, Secretary Davis said, in part:

The Mississippi River flood problem is the most important problem before the War Department today. The disaster of 1927 must not be repeated.

The first task before the Department was the closing of the gaps made in the existing lines of defense. A way has been found whereby funds in sufficient amount can be used for this work. Our lines of defense will be closed before the next flood season. We will not be able to extend or augment them, but we will be no worse off than we were a year ago. The present levee line is designed to protect against the largest flood experienced in the 150 years prior to 1927. Although not entirely completed to standard grade and cross-section, it would seem that by all the laws of probability we should be reasonably safe until the revised project can be started. In fact, of over 200 breaks which occurred in this unprecedented flood, I am told that only 15 were in levees on which the government had done any work whatsoever, and only one in a levee which was actually completed to standard dimensions, and that one by overflow and not by a break through.

The plan for the future must be sound in its engineering and in its economics. It must be one complete and co-ordinated whole, and carried to completion as rapidly as practicable. The people of the delta section get water from a total of 31 states and 2 Canadian provinces. They cannot cope with the problem by themselves. It is national. The federal government must bear most, if not all, of the expense. The protection of 30,000 square miles of land, some of it the richest farming lands of the world, justifies a large expenditure. Over 150 engineers of the War Department, some 30 engineer officers and 120 civilians are engaged in preparing a comprehensive plan to be submitted to Congress in December, which will meet the specifications I have just outlined.

On Thursday, the Mississippi River flood control problem was taken up again, this time by the waterways division, with Gen. Edgar Jadwin, Chief of Engineers, the man primarily responsible for the assembling of the data upon which Congress must act, presiding over the meeting, a fact which served in no small way to emphasize the importance of the proceedings. In general the papers dealt with special features of the problem like spillways or reservoirs, except for a more general paper by Col. C. W. Kutz, reviewing the work of the Mississippi River Commission, from which we plan to quote at some length in a later issue.

The surprise of the day came in a paper by Arthur E. Morgan, president of the Dayton-Morgan Engineering Co. and of Antioch College, in which he severely criticized the Mississippi River Commission for its attitude toward the whole problem, especially for (1) defective estimates of cost, (2) errors in estimating the amount of work still to be done in completing the levee system, and (3) complete failure to obtain data on reservoir possibilities or flood contingencies. Though couched in polite language, the charges were so specific and so serious that they caused no little sensation, particularly as the Secretary of War was sitting in at the meeting when they were made.

Many of the papers were directed toward some one feature of the flood control problem, but most of them included some opinion as to the whole problem. One gained a fairly distinct impression that the present is no time for the preparation of such a complete and com-

prehensive plan as Secretary Davis seems to expect. Not only is accurate information lacking on many of the details, such as reservoir sites and capacities, but there are no accurate maps of the region. A surprising thing about the meeting was complete absence of formal papers or discussions advocating any one of the many fantastical solutions of the flood control problem which have been brought forth during the past summer.

Specific Recommendations

H. C. Frankenfield, head of the river and flood division of the Weather Bureau, opened the Thursday morning session with a paper on rainfall characteristics of the Mississippi drainage basin. Dr. Frankenfield demonstrated by a series of charts and tables that the "Great general and never-failing type of rain producer, whatever its origin may be, is a well defined low-pressure area moving in some easterly direction—usually northeast or east-northeast—with a relatively cold high-pressure area to the northward or northeastward." The precipitation over the Mississippi drainage basin is at a minimum at its extreme northern and western boundaries, and increases steadily to the eastward, southeastward, and southward. Of the low-pressure rain-producing areas the most serious are those which move northeastward through Texas and up the Ohio valley, sometimes in a series with intervals of three or four days, a condition which is bound to produce a major flood. In 1912, there was a series of six of these storms separated only by an interval of a few days.

From Kansas City eastward, Missouri River floods are quite frequent, although not great; they occur usually in late June and July. Upper Mississippi floods are more numerous; they are almost entirely spring floods. Floods of the Ohio, Arkansas, White, Red and Lower Mississippi Rivers are virtually of annual occurrence and great floods are not at all infrequent.

In answer to a question frequently asked of the Weather Bureau as to what would have been the maximum crests reached during the flood of 1927 had all the main levees remained unbroken, Dr. Frankenfield finds that there would have been no great difference above Helena, Ark., but that at Arkansas City there would have been an increase of about 8 ft., 7 ft. at Greenville, 6 ft. at Vicksburg, 8 ft. at Natchez, 7 ft. at Baton Rouge, and a little over 6 ft. at New Orleans.

A paper by N. C. Grover, chief hydraulic engineer of the U. S. Geological Survey, on runoff characteristics of the Mississippi River drainage basin, tied in closely with that of Dr. Frankenfield, especially in the matter of quantity of water to be handled in the river below Cairo. In the 1927 flood, with 2,000,000 sec.-ft. passing Cairo and 1,500,000 sec.-ft. coming in from the tributaries below that point, there was an apparent total flood discharge to be handled in the lower river of 3,500,000 sec.-ft. Although no such total discharge occurred, due to relief by storage in the overflow area and the discharge of water down the Atchafalaya valley, yet, as the capacity of the river channel at New Orleans with the levees intact is about 1,500,000 sec.-ft., it is evident that in order to handle a similar flood lateral storage and additional channels must be provided if the river is to be kept within its banks. Reforestation and the storage of water on the headwater tributaries cannot be counted upon to affect the maximum floods materially, but they should be considered, as an added factor of safety.

Col. C. McD. Townsend in a general statement of the Mississippi River problem emphasized first that the building of levees by federal agencies purely for protection from overflow was specifically prohibited by Congress for many years. On this point he said:

> It will be noted that in all these acts of Congress, while the authority of the United States over levees and its financial assistance have been progressively increased, there has been considerable care exercised to preserve a servitude on the lands which are to be benefited. As Comptroller General McCarl has recently stated, the primary obligation for protection of private property adjacent to the streams for which co-operation between local interests and the Government has been provided rests upon the individual states or subdivisions within which the private property is located, the Government's part being to assist financially in connection with the maintenance and development of the river as a navigable stream only in proportion to the amount made available by such state or subdivision.
>
> Under this construction of the law the question of servitude becomes the most important problem which Congress must consider in any project for an extensive development of flood protection. The states have transferred it from the riparian owner to the various levee districts. Shall it now be assumed by the state or by the Federal Government? It is evident from the results of the last flood that the cost of any project for absolute security will far exceed the capacity of the riparian owners to meet their portion of the expense provided by existing law. It is also apparent that the farmer tilling the less fertile hill lands of Arkansas and Mississippi will never consent to an increased taxation for the purpose of further increasing the value of the plantations in the delta region and insuring the maintenance of such values.

Commenting upon the probable effect of the greater runoff of the flood of 1927, Col. Townsend said:

> While both Humphreys and Abbot and the Mississippi River Commission came to the conclusion that levees were the most practicable and most economical method of flood protection, they based their argument on an assumed flood discharge, and it by no means follows that such flood discharges as are now being discussed as possibilities can be more cheaply controlled by this method. Any project which contemplates increasing the heights of existing levees at certain localities some 15 ft. not only affects the item of cost but raises the question of practicability and feasibility of maintaining such a levee line after it has been constructed. Wherever the Mississippi River flows in a channel 30 or 40 ft. deep, it has powerful erosive force, and to expose levees in concave bends or cross points to such a force would invite their destruction.
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> The cost of the existing methods of levee construction increases as the square of the height, and if absolute protection is demanded for such levees as indicated above, the cost over existing methods will probably approach the cube of the height. The cost of a weir is independent of the height of the water flowing over it, and the cost of a dam is approximately a direct function of the quantity of water which it impounds. If *possibilities* instead of *probabilities* are to control future levee construction, the cost will become so enormous that the economic solution of the problem will be found in other methods.

Referring to reservoirs, Col. Townsend stated that the flood of 1927 clearly demonstrated that the only reservoir or reservoirs capable of controlling the waters which created it must be located in the delta region below Cairo, i. e., in the area which it is desired to protect by their construction. In relation to reservoirs in that region, he points out that while it might have been possible to obtain land in the St. Francis basin for that purpose at the time of Humphreys and Abbot, it would not be economically possible to purchase land

for that purpose at the present time. This condition, he believes, eliminates reservoirs from consideration and concentrates attention upon spillways. Col. Townsend stated that for years he has advocated the increased use of the Atchafalaya river as an outlet and the construction of a spillway below New Orleans. In view of the results of the 1927 flood, he thinks that it may be found practicable to divert the flow of the Arkansas and White Rivers along with that of the Red River from the main stream down the Atchafalaya Valley. However, he points out that while this diversion will relieve the main river and would add to its reservoir capacity, it would not reduce the flood heights at Simmesport to 46 ft. as required by the act under which the present spillway board is operating, and that the determination of flood heights along the diversion channel would be a problem difficult of solution for the next 20 years, during which time the diverted flow would be excavating its bed. The cost of this diversion Col. Townsend says may be many hundred million dollars less than that of any other project that will afford complete protection from any possible flood. Yet it is still so great as to raise the question whether the increase in value of the land to be benefited would justify the expenditure.

Of the other possible means of relieving the floods, such as reforestation, straightening of the river, enlarging its low-water channel with dredges and increasing its reservoir capacity by placing the levees at a greater distance from this channel, he said that the latter is the only one now being seriously considered. This also, he believes, is of questionable practicability on account of its great cost, reduction in taxable land, and the possibility of silting.

Referring to possible changes in the levee sections, Col. Townsend pointed out that the present commission's section was evolved from suggestions which he made prior to 1896 when he was serving with the commission and that it has been employed on a levee line 1,400 miles long during a period of over 30 years without a failure from weakness of section until the flood of 1927, the failure occurring in a section composed of material which, he stated, he would not have used without enlarging the section at the time he was in charge of such work. Now it is proposed to expend some $40,000,000 in enlarging the section. Col. Townsend states that before going to such great expense he recommends that more study be given to the causes of failure in existing levees as he is of the opinion that failure is due rather to outside influences than to the makeup of the section.

In conclusion, Col. Townsend states that while Congress has been extremely liberal in its appropriations for the Mississippi River, any one who expects that it can be persuaded to appropriate from $50,000,000 to $100,000,000 per year for a period of 10 years for the Mississippi alone has little knowledge of the workings of the congressional mind.

Col. Townsend favors the construction of levees at a grade 3 ft. above the stages of a *probable* flood at various stages on the river rather than attempting to build a levee system which would meet the requirements of a *possible* flood. On this point, he says:

> When it is stated that a flood like that of 1927 will not probably occur again in 100 years, the engineer must take into consideration probabilities instead of possibilities, and consider the interest on investment for a period of 100 years. If the interest is computed at 4 per cent on the cost of some of the proposed projects, it would be greater in 15 years than the estimated damage caused by the flood. A disaster which will not probably occur once in 100 years is in the same category as an earthquake or cyclone. It is an Act of God for which the philanthropist should make provision. Because an earthquake formed Reelfoot Lake opposite New Madrid 100 years ago, engineers do not make the buildings in the Mississippi Valley earthquake proof.
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> The final suggestion is also submitted that no matter how much money is expended on the levee line, it will still be at the mercy of the combination of a muskrat, a dark night, and a careless levee inspector. A burrowing animal can create a hole in the finest levee which has been devised, which if not closed within a few moments will insure its destruction. Perfection is difficult in all engineering enterprises. To try to construct a levee line which will resist the river flow under all the imaginary conditions which now fill the public mind, is to attempt the impossible.

The Wednesday afternoon session closed with the address by Col. George R. Spalding, previously noted. While not claiming to be an expert on the Mississippi River problem, Col. Spalding said that his work in charge of flood relief impressed him with the fact that the river needs more room. He believes that the present levees should be made safe for normal conditions and that some basins and side channels should be left for the express purpose of storing and taking off excess flood flows. The use of such basins for agricultural purposes could be so limited as to prevent a repetition of this year's disaster.

Reforestation—Another side of the flood control problem was presented by E. F. McCarthy, director of the Central States Forest Experiment Station at Columbus. His chief point—but one which he did not prove—was that while forests cannot be counted upon to prevent floods, they can be used to reduce their intensity and to prevent erosion, and so reduce the amount of silt carried by the stream. The Forest Service estimates that the storage capacity of forest humus is approximately equal to 1 in. of rainfall over the entire area.

Reservoirs—Two papers, one by William Kelly, formerly chief engineer of the Federal Power Commission, and one by F. W. Scheidenhelm, consulting engineer, New York, dealt largely with the relation of storage reservoirs to flood flows. They pointed out that while power development and flood control cannot generally be satisfactorily served by the same reservoir, yet the two demands are not entirely incompatible. However, as Col. Kelly pointed out, reservoirs may in some instances be detrimental, in holding back water in one tributary sufficiently to make its flood crest coincide with that in a lower tributary. The reservoir board, of which Col. Kelly is a member, has found a total of 320 possible reservoir sites in the valley, of which 120 upon study were found to be valueless and many of the others appeared to be too costly to be considered. However, estimates showed their combined capacity to be 110,000,000 acre-ft., or about one-fifth of the flood flow. If it was possible to fill them all, they would make a reduction in the flood flow of 350,000 sec.-ft. at Cairo. They would cost approximately $1,313,000,000. The board has not found any project where reservoirs solely for Mississippi flood control are justified, but when combined with other uses it may be that their cost can be reduced sufficiently to justify construction.

Levees Only—J. F. Coleman, of New Orleans, in his paper on levees, came out frankly as one of those who believed "that levees and bank revetment without the aid of reforestation, contour plowing, reservoirs, outlets or

spillways, will most surely provide the necessary control for the floods of the Mississippi River." The levees-only or confinement plan is based on the theory that in an alluvial bed or channel the energy and power required for channel enlargement may best be obtained by so confining the flowing water that its velocity will be increased and its scouring capacity will be put to the useful purpose of enlarging the channel. According to the same theory, the removal or diversion of any part of the water from the stream reduces the velocity and consequently the energy of the main stream below the point of divergence and results in deposits of silt and reduction of cross-section of the main channel, and hence reduces its carrying capacity. Mr. Coleman believes that the results of past experiences on the Mississippi and many similar rivers support this theory. Such being the case, he holds as follows:

> We must either close the mouth of Old River and confine all the waters of the Mississippi River within the channel of that stream, or we must close the Mississippi River just below the mouth of Old River and divert the water to the Gulf of Mexico through the Atchafalaya River. The latter route is shorter by 150 miles, but the volume to be provided for would be greater than in the former case by the addition of water from the Red River and its tributaries.
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> It seems to the writer that the first step to take in a study of this great problem is to determine with as much certainty as possible whether it is better to concentrate the flood waters in one channel, or split these waters up into two or more channels by maintaining the Old River outlet and by creating other outlets and spillways. When the broad general principle is settled, it will be time enough to attempt the determination of other points.
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> If the problem were merely to deal with the control of floods for a few years, perhaps spillways or outlets would serve. But the problem is to provide for all posterity, and it appears to the writer that the advantages that may be gained by spillways are not only temporary, but that they are at so enormous a cost for the future that it would be an engineering mistake to formulate designs of flood control based upon a system of spillways.

The relation of improvement for navigation to flood control work was pointed out in a paper by Maj. S. C. Godfrey, especially in the matter of bank protection and other devices for preventing the formation of bars. He stated that under normal circumstances the bars which form during floods are cut away subsequently if the fall is not too rapid, also that bars normally form in the river below crevasses.

The special problems at New Orleans were described by Marcel Garsaud, general manager, Board of Port Commissioners at New Orleans. He favored the use of spillways both above and below New Orleans as the only safe means of preventing the river from overtopping the levees at that point. Not only is there considerable evidence that the levees at New Orleans cannot be raised indefinitely due to the character of the underlying material, but also the effects of the past floods show that any great increase in velocity of flow past the city would cause dangerous erosion. He believes that spillways can be built which will adequately serve the purpose without resulting in dangerous scour such as is feared by some of the engineers of the Mississippi River Commission. He favors increasing the capacity of the Atchafalaya channel to permit the diversion of 1,100,000 sec.-ft. through that river.

Experience on other streams was outlined by M. G. Barnes, of the Division of Waterways of the State of Illinois, and by C. E. Grunsky, of California, the latter describing work on the Sacramento River in California, where relief outlets and by-passes have been used to a considerable extent. Morris Knowles also outlined some of the studies which were made at Pittsburgh, Pa., for the control of flood waters at that point. He cautioned against hasty action in preparing a plan for the Mississippi floods. The same note was sounded by Charles H. Paul in reviewing some of the work done on the Miami control reservoirs.

The effect of drainage works upon flood flows was the subject of a paper by Prof. S. M. Woodward of the University of Iowa. Results of studies which he made upon one of the smaller rivers in the valley indicate that systems of land drainage have no material effect upon the rate of run-off.

Divergent views on "levees only" were expressed by Frank B. Maltby and C. S. Jarvis. Col. Maltby favored the construction of larger and higher levees with no attempt to provide reservoir areas in the delta region while Mr. Jarvis expressed the view that the river needed more room and that the "levees only" theory will never prove satisfactory. From a somewhat different viewpoint F. G. Jonah, chief engineer of the St. Louis-San Francisco Ry. expressed the view that the St. Francis basin was too valuable to be devoted to overflow. He favored a by-pass channel down that valley to gain on the flood crest, also an enlarged outlet down the Atchafalaya valley.

Speaking in opposition to the views of those opposed to spillways, Roger B. McWhorter of New Orleans stated that the results obtained at the Caernarvon and other crevasses showed that if spillways are made sufficiently long there need be no scour or serious silting below them; also that the results obtained in deepening the river by confinement are inconclusive, that the flood heights never have been materially reduced.

Three Important Structural Papers

At a session of the Structural Division of the society three important papers were presented, discussing new observations and theories, respectively in the fields of bridges, general structures and high buildings.

Arch Bridge Expansion—Prof. W. M. Wilson, of the University of Illinois, reported extended measurements of temperature effects in a six-span concrete arch bridge, carried on during several seasons over a 20-month period, under the title "Observed Effects of Climatic Changes Upon a Multiple-Span Reinforced-Concrete Arch Bridge." The bridge crosses the Vermilion River at Gilbert St., Danville, Ill., and was built five years ago. It has unequal spans, each composed of two hingeless ribs carrying a deck slab by means of spandrel columns. The deck is cut by expansion joints at the piers, and in case of all but the end spans also at the ends of the saddle formed on the middle three panels, where the deck construction is integral with the rib concrete.

During the observation period the mean temperature of the arch ribs ranged over about 90 deg. F., and in one case changed 26 deg. in three days. The arch ribs rose and fell a maximum of 0.62 in., closely in accord with calculations on the basis of expansion rates of 0.0000049 in the rib and 0.0000056 in the deck. The total movement of the expansion joints, 5.37 in. at the maximum, agreed with the calculated expansions of the total deck lengths. Slight pier rotations resulted from the temperature thrusts, and neither these thrusts nor the dead-load thrusts gave truly central pier footing reactions. The expansion joints at the end of the saddles (middle

three panels) did not move, and in theory should not move appreciably, if rib bending and continuity of deck are taken into account. It was concluded that these joints should be omitted in design, and that care in the pier design to obtain uniform soil pressure is important.

Prof. George E. Beggs, of Princeton University, said that deformeter measurements on models of three open-spandrel arches showed a reduction of 2 to 10 times in live-load bending moments by reason of the rigidity resulting from continuity of ribs, spandrel columns and deck. Important stresses in the columns and deck arise from this action. He explained how it is possible to measure with an arch model and a filar micrometer microscope the movement to be expected at expansion joints in an arch bridge floor, and also how one may experimentally observe the concentration of bending in the arch ribs near the floor expansion joints.

Prof. Hardy Cross, of the University of Illinois, emphasized the fact that only small savings in arch bridge design can be realized through making use of the integral action of ribs and floor, especially as live-load stresses are often much less important than the other stresses. With present imperfection of knowledge of soil pressures and settlements it is rather academic to analyze arch bridges by methods of high precision, he said.

Elastic Stability—"Problems of Elastic Stability in Structural Engineering," by S. Timoshenko, of the Westinghouse Electric & Mfg. Co., discussed in essentially theoretical manner those special conditions often occurring in structural aggregates where stability rather than stress controls the load-carrying capacity, as in buckling. The strength of built columns, of top chords of pony-truss bridges, and of webs of columns and plate-girders, was dealt with.

Commenting on this paper, Prof. H. M. Westergaard, of the University of Illinois, transferred the subject of elastic stability into a rather different field of application. In a suspension bridge of heavy unit weight the dead load steadies the structure and reduces the tax on the stiffening trusses. This case may be analyzed in terms of the critical loads which would cause the inverted suspension bridge (changed into an arch) to buckle. Prof. Wm. Hovgaard, of Massachusetts Institute of Technology, agreed with the author as to the general method of attack on the problems dealt with, and then briefly indicated the extension of the subject matter to phases of the design of ships.

Windbracing of High Buildings—A. W. Ross and Prof. C. T. Morris, of Ohio State University, reported the results of elaborate studies of the portal-type windbracing in the steel frame of the 48-story (555-ft.) American Insurance Union tower, in Columbus. The tower frame has 36 columns, grouped in six bents in each direction. The lower eight stories were analyzed exactly (by the slope-deflection method), and also by one of the conventional methods commonly used in design, namely the cantilever method (Wilson's method, or Fleming's Method I). The latter was shown to involve rather large errors, 20 to 100 per cent. But a check on the rigid method by Beggs Deformeter measurements on a cardboard model of the frame also showed some large discrepancies. By carrying through the rigid calculations for various ratios of stiffness of columns to girders, as compared with a particular "ideal" proportioning, the authors developed a set of correction curves for use in modifying the ideal theory for any practical case.

In discussion, F. E. Schmitt, of *Engineering News-Record*, conceding the theoretical importance of the portal-braced multistory bent, suggested that actual buildings do not consist of such bents, however, but are cellular structures of masonry and steel in co-operation. The action of the steel is conditioned by the action of the structure as a whole. Certain observations indicate that the structure deflects or bends integrally, and therefore departs radically from the form of deformation proper to the portal-braced bent alone. But even if the bent be considered as a detached unit, its action is modified basically by the stiffening effect of the floors.

The influence of the vibratory movement of tall, slender buildings on the essential design factors was emphasized by David C. Coyle, of New York. Mr. Coyle pointed out that lateral strength is probably over-emphasized, as service has shown no failures of tall buildings in lateral resistance except in two instances in the Florida hurricane of 1926, at a probable overload of some 200 per cent. The feel of steadiness, however, is a vital desideratum in all high buildings. "Wind bracing is not altogether a science, but in some ways an art," he said, "the adjustment of a material structure to the somewhat intangible requirements of the human nervous system; what we shall be judged by is in practically all cases the feel of the structure and nothing else."

Highway and Sanitary Engineering

Highways and Sanitation—Several interesting papers came before the Highways Division and the Sanitary Division. E. G. Bradbury, sanitary engineer of Franklin County, Ohio, read a paper on "Sewer and Water-Works Construction Under the County Sewer District Law of Ohio and the Assessment of Costs in Proportion to Benefits," while W. D. Hatfield and S. A. Greeley described the sewage disposal works of Decatur, Ill.

Highway transport surveys were discussed by George F. Schlesinger, director of the Ohio department of highways and public works. He detailed the outcome of an extensive traffic survey made on Ohio roads in 1925, when some 2,200,000,000 vehicle miles were operated on the 11,000 miles of state highway (out of 84,884 miles of total highway in the state). The survey led to the development of a five-year improvement program (1927-31 inclusive) to cost about $100,000,000. It involves much widening, as the system includes 4,800 miles of high-type road less than 18 ft. wide, 1,400 miles of this being only 10 to 15 ft. wide.

A. H. Hinkle, maintenance engineer of the Indiana highway department, read a paper on "The Engineer's Part in Making the Highway Safe." He showed that 30 per cent of highway accidents are due to causes lying in the highway, as against the driver's and the vehicle's shares. Curvature, sight distance, superelevation, widening on curves, grades, crown and other factors were separately discussed. He stressed the need of low crown, wide right-of-way and safe shoulders, among other things. "I have a record of one heavily traveled road which is paralleled by a deep ditch for four miles and which has claimed five lives in five years. Another record on an 11-mile stretch of road shows a loss in damaged vehicles of $24,000 per year." Narrow bridges also received attention. E. W. James, of the Bureau of Public Roads, in discussion spoke of a street grade-crossing elimination in Chicago, just completed, which has serious defects quite obvious on watching traffic pass over it, illustrating the present lack of understanding of traffic dangers.

Mississippi River Commission Severely Criticised

Arthur E. Morgan Finds No Satisfactory Reason for Its Rejection of Reservoirs—Levee Costs Understated

Speaking before the Waterways Division of the Am. Soc. C.E., at Columbus on Oct. 13, during a symposium on the Mississippi flood control problem, Arthur E. Morgan, president of the Dayton-Morgan Engineering Co., an engineer with a wide experience in river control work, made a severe criticism of the way in which the Mississippi River Commission has handled its work in the past. Reference to his statements is made in the report of the meeting. In view of their seriousness they are given in more detail herewith.—EDITOR.

THE speaker decided that the best contribution he could make to this discussion is to try to discover the exact nature of the evidence which had led the Mississippi River Commission to reject reservoirs.

The whole controversy has been almost hopelessly clouded by two factors. First, it has been made to appear as an issue of levees versus reservoirs on the assumption that they are mutually exclusive. Such is not the case. In a great problem like that of the control of the Mississippi it would be almost miraculous if 100 percent of the desired results could be achieved by only one method. The real problem is to discover and appraise all possibilities, and then, by careful analysis and synthesis, to design a total improvement in which each method is introduced to whatever degree is most effective.

So far as the speaker can discover, up to the year 1927 this attitude of endeavoring to work out a solution that will use all desirable methods never had been taken by the Mississippi River Commission, but rather the attitude of an armed camp in the battle of levees against other methods of control. General Chittenden, at one time Chief of Engineers of the United States Army, was the recognized authority against reservoirs. In deciding against reservoir control on the basis of cost, he referred to the report of the Mississippi River Commission for 1896 as authority for the statement, "Take $40,000,000 and reinforce the entire levee system of the Mississippi. That will make it impregnable."

In 1896 the levee system was only well begun. If $40,000,000 would make it impregnable, then it was almost certain that reservoir control would be more expensive. In 1896 the Mississippi River Commission estimated the cost of completing protection at $18,000,000. In 1912 the president of the commission stated that $73,000,000 was ample to do all remaining necessary work. In 1924 the Chief of Engineers stated that 90,000,000 yd. would complete the work. In 1925 the president of the commission said:

"There are now completed or nearing completion 1,824 miles of levee line on the Mississippi River, requiring about 76,000,000 yd. to finish it. That would have been the end of the commission's levee building, but for the fact that Congress has recently extended the commission's jurisdiction to the tributaries."

I believe I have quoted enough to indicate that the estimates of the Mississippi River Commission have been inadequate. These estimates of the cost necessary to complete the levee system seldom have been more than 20 percent of the true cost, and generally less than 10 percent. I believe that this extreme inadequacy of their estimates has rendered difficult, if not impossible, any dependable comparison between the cost of levee protecton and of reservoir protection.

On the other hand, until a few months ago there has not been even a remote effort on the part of the commission to discover and to estimate the cost of the most favorable opportunities for reservoir control. Thus we have the remarkable situation of 50 years of vehement insistence of the superiority of levees over reservoirs, without a thoroughgoing engineering analysis of the cost of either.

In the preparation of the present paper, however, the speaker has hunted assiduously for those deep researches and critical studies so often referred to by the Mississippi River Commission and by the army engineers. To his astonishment, he finds they never have been made.

Following back to original sources one finds the report of the Engineering Board of 1874, which led to the establishment of the Mississippi River Commission. In this report, so often referred to as authoritative, we find expressed a fundamental misconception of the proper operation of flood control dams, followed by this conclusive remark:

"The question of absolute practicability could only be decided by a series of extensive and elaborate surveys, for which neither funds nor time were available, nor in the opinion of this commission are they needed. Here, as elsewhere in the valleys, this plan, as an efficient means of restraining the floods of the Mississippi, is chimerical."

This board estimated the total cost of complete protection by levees at $46,000,000. Coming down from that early date to recent years we find one of the last affirmations of the attitude of the Mississippi River Commission and the army engineers in the Committee on Floods and Flood Control of this society. The chairman of this committee was president of the Mississippi River Commission, and the report presents the orthodox Mississippi River Commission attitude, with slight concessions and some caution. In deciding against reservoirs and in favor of levees this committee states that for rivers like the Mississippi and the Colorado levees are the only sure means of flood control.

The Army and the Commission have practically controlled the purse strings for the Mississippi. An adequate analysis of the problem would require years of time and very considerable funds for the accumulation and analysis of data, and they have been the only ones in position to make that study. The commission is not to be censured for not quickly understanding the problem, but for ignoring it, and for letting the years of its stewardship pass without a definite study of the entire Mississippi problem.

If there should be one chance in ten that reservoirs can play an important part in the control of the Mississippi, then it is unscientific and unprofessional finally to establish an engineering policy for the control of the great river without having thoroughly examined into that possibility.

The speaker is convinced that the examination necessary to determine those possibilities never has been made. He strongly believes that for the national congress to be committed to a permanent policy with reference to flood control on the Mississippi, without such inquiry, will be a mistake of historic magnitude.

Sink Hole Topography Study for Sewage Disposal

Investigation at Alton, Ill., Indicates Underground Flow Would Enter Mississippi River Above Water-Works Intake

By J. E. LAMAR
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A PROPOSAL by the city of Alton, Ill., to dispose of sewage from a rapidly growing subdivision by emptying it into a conveniently located sink hole resulted in the Illinois Geological Survey being called into consultation by the division of sanitary engineering of the State Department of Public Health. The question raised was whether the sewage thus discharged would enter the Mississippi River at a point above the water-works intake of Alton, which the investigation answered affirmatively.

The section to be sewered is located on the edge of an area of Karst, or sink hole topography, and cannot be connected with the existing sewers without considerable cost. The surface drainage of this section is carried off through a sink hole, and it was proposed to dispose of the sewage in the same manner.

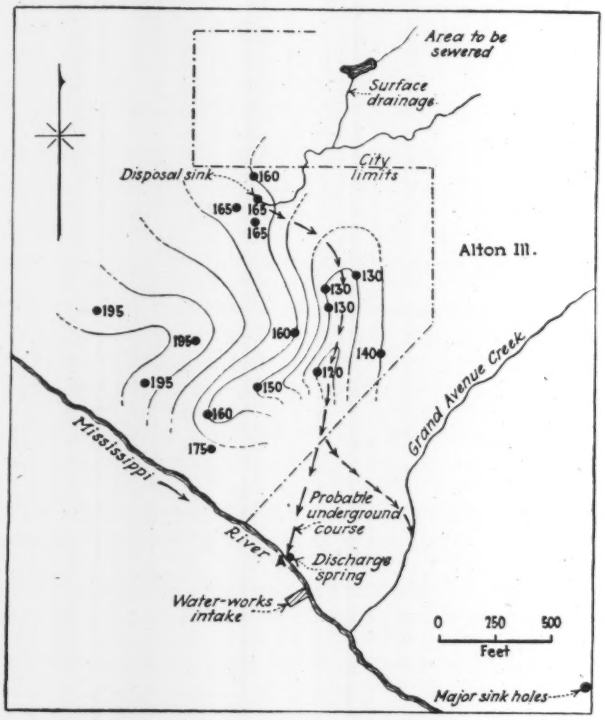
One of the factors influencing subsurface drainage is the character of the rock formations. These were found to be the basal Ste. Genevieve and the upper St. Louis limestone. The Ste. Genevieve formations are for the most part a pure limestone, locally oolitic. The St. Louis limestone consists of thin, medium and thick beds of limestone, some of which are very pure and others very argillaceous. One bed in question is located in the bluffs about a mile and a half above the business district of Alton, and is about 12 in. thick, lying beneath a brown layer about 18 in. thick which in turn underlies the conglomeratic beds of the upper St. Louis. This bed is highly argillaceous and is responsible for numerous springs and seeps, as well as a rather extensive development of underground aqueducts descending to its general level irrespective of the elevation above the Mississippi River.

The dip of the limestone exposed in the river bluff, approximately S. 20 deg. E., varies greatly, due to local warpings and in general is thought to be from 1 to 2 deg.

In the area under consideration there are two principal and rather pronounced sets of joints, one extending about N. 60 deg. E., the other N. 45 deg. W. The former is the most important in influencing subsurface drainage as by far the greater number of underground water channels which could be observed slope in the direction of this set of joints.

The sinks vary in size from relatively large depressions about 300 ft. in diameter at the rim and 60 to 80 ft. deep, down to 10 or 20 ft. in diameter and proportionately shallower. Many of the sinks show limestone in their funnels and a few are the termini of small surface drains.

From a study of field evidence the following conclusions are thought to apply to the sinks of the region. (1) The water draining into the limestone sinks descends through enlarged crevices and joints in the rock, moving principally downward until it reaches a layer of limestone which, because of its argillaceous or siliceous character, is less pervious and soluble than the rock. (2) The joints in the argillaceous beds tend to become clogged by residual material from the solution of the calcium carbonate from the rock, and by settlings from the descending water whose movement may be partly or wholly impeded by the argillaceous beds. (3) The water moves laterally along the less soluble beds until it encounters crevices or joints which have not been closed and permit further downward flow. (4) The water entering sinks other than those immediate to the river bluff, flows in rather well-developed, mature subsurface drainage systems. (5) The sinks near the river bluff probably drain toward the bluff and the water which they collect escapes through the caverns in the bluff. (6) The age of a given sink relative to others in the same region and rock formation is generally indicated by its size. The larger and deeper sinks are the older. (7) The alignment of the older sinks indicates the route of the oldest underground water channels and these are probably the course of the major subsurface drainage.



ELEVATIONS OF BOTTOMS OF MAIN SINK HOLES
Taken from topographic map loaned author by J. E. Schwab, city engineer, Alton.

With the foregoing points in mind, the accompanying map was made showing the contour of the bottoms of the larger sinks throughout the area and the alignment of the older sinks. This suggests that the water entering the proposed disposal sink probably would take the southeasterly course for about 700 ft., as indicated by the arrows on the map. This course is possibly induced by the N. 45 deg. W. joint system. Then, the underground drainage turns almost due south with an elevation of 120 ft. and from this point the direction of flow is indeterminate because of lack of elevations on sink bottoms. Either the N. 45 deg. W. set of joints would be most effective in influencing the course of the drainage and it continued southeasterly to the Grand Avenue Creek system, or else the effect of the major system of joints, the N. 60 deg. E. set, would result in the discharge of the

water from the spring at the point *A* in the Mississippi.

Fluorescein was introduced into the stream of water entering the disposal sink. After 2½ hr. it had not appeared in any of the probable points of discharge. By the following morning, however, the spring at *A* was flowing green water, which color persisted for about 200 ft. out into the Mississippi River. Examination of other springs along the river bluff failed to reveal the discharge of any dye-colored water.

From these investigations, it seems possible to determine the general direction of the flow of underground water from the contours on the bottoms of the major sinks of the region, in addition to having data on the jointing of the area and its effect on subsurface drainage.

Carbon Dioxide Treatment at St. Louis Water-Works

By A. V. Graf
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CARBON dioxide as a corrective measure and as a further refinement in the purification of water is to be used by the city of St. Louis, Mo. Two plants for producing carbon dioxide will be installed, one having a capacity of 40,000 lb. per day, to treat 160 m.g.d., at the old works, and another of 20,000 lb. capacity, to treat 80 m.g.d., at the new plant. The installation at the old plant will be made within a few months, but that at the new plant will not be completed until 1929. The amount of water now being filtered at the two river works averages about 130 m.g.d. Each carbon dioxide plant will consist of a gas producer burning coke; a combined washer, scrubber and drier; gas burner, compressor or blower, and the necessary gages for the control of operation.

The amount of softening done at the St. Louis filtration plants has been limited to the removal of part of the bicarbonate hardness, and only occasionally has the water been treated with enough lime to render it caustic and thus increase the amount of magnesium removed. No soda ash is used. The normal carbonate alkalinity of the settled water varies from 22 to 67 p.p.m. and that of the water applied to the filters from 2 to 30 p.p.m. This reduction in the normal carbonate is due to the use of aluminum sulphate as a secondary coagulant. In spite of this low carbonate alkalinity the coating on the filter sand now amounts to 17 per cent of the filtering medium.

Before filters were installed, in 1915, the normal carbonates exceeded the amount now present in the tap water, yet for 12 years few general complaints were received; but there were many complaints from users of instantaneous water heaters, when, for short periods, the normal carbonates exceeded 30 p.p.m. and the small space around the thermostat tube (about ⅛ in.) would become clogged with precipitated lime and magnesium salts. Since the filtration plant has been in operation less trouble has been experienced because of the reduction of the normal carbonate content of the tap water; but enough precipitation still takes place in hot water pipes to warrant the use of carbon dioxide. Due to the alkaline character of the water, there is a decided action upon the zinc of galvanized pipe, and this continues until a protecting coating of lime and magnesium salts is formed. In operating the carbon dioxide plant it will be necessary to keep the water free from uncombined carbon dioxide so that this protective coating will not be removed and result in red water.

At plants where soda ash and lime are used, and the water contains free calcium hydroxide, much more trouble from incrustation is experienced. By the use of carbon dioxide the calcium hydroxide is converted to calcium carbonate and is precipitated in an amount depending upon the solubility of the calcium carbonate at the temperature at which it is formed. If it is not precipitated, it must be converted to calcium bicarbonate. Seventy p.p.m. of calcium carbonate will remain in solution with water at a temperature of 33 deg. F.

The use of carbon dioxide as an adjunct to water softening is not of as recent origin as most water-works men may believe. In 1892, Archbutt and Deeley used carbon dioxide to stabilize the softened water for the stationary boilers of the Midland Railway at Derby, England. This treatment, known as the Archbutt-Deeley process, was patented in 1894. At about that time, the new municipal plants at Swadlincote and Ashby installed this method of water treatment. The first use of carbon dioxide in a municipal plant in America was at Winnipeg, Manitoba, about 1902, but its use was discontinued when a new source of supply was introduced. In 1920, a carbon dioxide plant was installed at Defiance, Ohio, and a rapid increase in the number of water purification plants using carbon dioxide followed this successful installation.

What Type of Bridge

FOR the crossing of any stream, large or small, one of the first questions that must be settled is the general type of structure to be adopted, and the selection is confronted by a rather forbidding array of factors. In a recent discussion before the Western Society of Engineers on this subject, Dr. J. A. L. Waddell stated that for any given crossing there is one best type of structure to meet the conditions and one best arrangement of spans and piers. Assuming that all governing conditions, such as clearances, are met, and that the esthetic aspect is not a governing consideration, then the best arrangement or layout will be that which provides satisfactorily for traffic requirements and which will be the most economical in first cost, maintenance, operation and length of life. In general it has been difficult to persuade officials or promoters to allow sufficient time or money for investigations. But with the recent development in toll-bridge projects there has come greater opportunity for preliminary study.

Among many auxiliary factors to be considered are foundations, grades on structure, approaches, cost of shop and field work, erection methods and time required for construction. Various alternatives also enter into consideration: High or low level, long or short spans; deck or through spans; alloy steel or carbon steel, and concrete or steel. The number of factors and alternatives is greatest with spans of moderate length, but in short spans and trestles there are various alternatives and combinations of steel, concrete and timber. Except for very long spans, Dr. Waddell considers that the suspension type is neither efficient nor economical in bridges to carry steam railways, although this type is cheaper than the cantilever type in spans of more than 1,000 ft. for highways and electric railways.

Engineering Literature

A Monthly Review of Books and a Listing of New Publications

Stodola in English

STEAM AND GAS TURBINES, With a Supplement on The Prospects of the Thermal Prime Mover—By Dr. A. Stodola, Professor at the Polytechnikum in Zurich; Authorized translation from the sixth German edition by Dr. Louis C. Loewenstein, Consulting Engineer. In Two Volumes. New York and London: Mc-Graw-Hill Book Co., Inc. Cloth; 7 x 11 in.; 1,356; 1,565 halftones and line cuts and 7 folding charts, $15.

The first four editions of this valuable work, in its German form, were reviewed in *Engineering News*, 1904 to 1910, by the late Prof. Storm Bull. The fifth edition, embodying extensive revision, appeared in 1922. The sixth edition, here fortunately made available in English, contains some but not much new material. The many American and British engineers who have occasion to follow gas and steam turbine practice and who are so unfortunate as not to read German, readily if at all, will welcome this translation; all the more so because the only earlier English version, based on the second edition, is now out of date. An extended review of the English translation of this latest German edition may be found in *Mechanical Engineering* (Engineering Societies Building, New York City) for October, 1927, the review being from the pen of Prof. Lionel S. Marks, Harvard University.

Stimulative But Irritating

YOUR MONEY'S WORTH: A Study in the Waste of the Consumer's Dollar—By Stuart Chase and F. J. Schlink. New York: The Macmillan Co. Cloth; 5x8 in.; pp. 285. $2.

Messrs. Chase and Schlink have written a most stimulative book, and at the same time a most irritating one. It is stimulative in revealing and analyzing extensive wastes, losses and deceptions that result from the prevalent buying habits; it is irritating in being written with so much hyperemphasis as to invite and earn prompt disbelief—it contains quite as much misinformation, misstatement, and vituperation as the exhortation of a fanatical reformer. It is disappointing in that, unlike the reformer, the authors have no sure escape to offer from the evils which they cartoon. So their book has the principal effect of stating a problem—one of the big problems of the modern world, it is fair to add.

The theme of the book is not precisely expressed by the title; it is not an explanation of how to get your money's worth, but the assertion that you don't get your money's worth. In this form it is bound to be resented by most readers, the more so as it oversells its ware. The details of the portrayal, how they conjure up the fancy of the entire modern world being one vast riot of patent-medicine quackery, must be left for the reader himself to trace out.

Standardization is the beacon of hope they offer. And in speaking of it they again mis-state and overstate in an unfortunate way. "There stands the Bureau of Standards, a beacon on a hill," they say on an early page. Again they say that without standards "the door is thrown open to the charlatan, the incompetent and the profiteer . . . the odds against the honest and painstaking manufacturer are impossibly high." Which means, if it means anything, that there are no honest and painstaking manufacturers! Still farther on: "In the absence of standards, and straight line volume production, a lathe or planer will cost around one dollar per pound, while the standardized motor car may be bought for 30 cents a pound—less than the cost of butter by the tub! *No more startling illustration of the value of standards could well be given.*" The italics are ours.

The book is strongly recommended to the reader. Patience is advised in reading it, as well as careful, skeptical reflection on what the authors have to say. In gross, they state a problem of great size. A solution is not shown, but each reader will automatically contribute to the solution by thinking over the facts which the book presents—after sifting out the great mass of misstated and irrelevant matter from the modest amount of pertinent truth.

Stream Gaging by the Current Meter

REVIEWED BY ROBERT E. HORTON
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STREAM GAGING—By William Andrew Liddell, S.B. New York and London: McGraw-Hill Book Co., Inc. Cloth; 6x9 in.; pp. 238; illustrated. $3.

It is apparent that this book is intended both as a textbook and as a working manual for engineers having to do with stream gaging—principally by the use of the current meter, since 175 out of the 220 pp. of the main text apply primarily to methods and apparatus used in stream gaging by this method.

So far as the treatment of current meter gagings is concerned, the subject is presented as a whole in a most excellent manner. Successive chapters cover the distribution of velocities, selection of current meter gaging stations, types of gages, types of current meters, rating of current meters, current meter characteristics and the effect of turbulence, details of current meter measurements, determination of area of cross-section, the construction and use of station rating curves and the effects of ice on discharge measurements at current meter stations.

Interlarded with this material and seemingly somewhat out of order and very incomplete are brief sections dealing with gaging by floats, by weirs and by the slope formula. The reason for treating the unrelated slope and weir methods under one heading is not apparent. The slope method is rarely used as a means of obtaining a continuous record of stream flow. The discussion of the weir method relates almost wholly to the use of thin-edged weirs. Such weirs are not generally used, nor are they usually adapted to obtaining continuous records for other than relatively small streams.

Nothing is said about the rapidly extending use of records kept in connection with modern power developments for the purpose of obtaining continuous stream-flow records, although brief mention is made of the matter of selection of coefficients of discharge for dams under the caption "Broad-crested Weirs." Most of the dams now built in connection with power development, and used for determining stream flow are not, properly speaking, broad-crested weirs but have crests of the ogee

type, a form so nearly standardized that there is little difficulty in the selection of proper coefficients by persons having adequate knowledge and experience and with a degree of accuracy at least equal to that of the average current meter station rating curve. As the author suggests, some additional experimental data are needed. Auxiliary methods used in connection with gaging records at power plants, particularly for calibration of turbines, such as the Gibson method, the use of pitot tubes and the salt velocity method, are not mentioned.

With reference to coefficients of discharge for dams, given in U. S. Geological Survey Water Supply Paper No. 200, the author of this book states (p. 183): "These values were obtained from an exhaustive study of two series of experiments on broad-crested weir coefficients made independently by Bazin, in 1897, and Rafter, in 1898." He overlooks the fact that by far the most extensive and useful series of experiments given in the water supply paper mentioned is the one made in 1903 under the reviewer's direction at Cornell University for the U. S. Geological Survey.

There are hundreds of streams for which the current meter method of gaging is the only available method. On the other hand, there are numerous streams in the eastern states, and they are the most important power streams, to which the current meter method of gaging either is not applicable because of the lack of situations free from backwater, or is unsatisfactory owing to the impossibiliity of securing continuous records in winter. As is well known, the hydraulic turbine is an excellent water meter and the discharge capacity at various gate openings of very many hydraulic turbines now in use has been accurately determined. Not only are records kept at dams and power plants in many instances the only ones available on a stream, but records often have important advantages over records obtained by the current meter method. This is especially true where the entire flow during the winter is used through the turbines, thus wholly eliminating the bugbear of ice conditions affecting current meter station rating curves. Again, it is nearly always possible to obtain flood peak discharges with certainty, as the accuracy with which the discharge over a weir or dam can be determined by calculation generally increases as the depth of overflow increases. The ordinary natural control for a current meter gaging station is at its best merely a natural weir or dam, the rating curve for which is derived by current meter measurements. A modern spillway dam with ogee crest forms a permanent, definite "control," far more reliable than the average natural control attainable for current meter stations.

Reverting to the subject of gagings by the current meter method, Chapter II treats briefly the general laws and facts relating to the movement of water in rivers. Reynolds' critical velocity and the nature of turbulent motion are mentioned and the interesting suggestion is made that when a rising stream reaches a certain stage and velocity, the maximum degree of turbulence is attained, while for higher velocities the flow in the body of the stream is mainly laminar. This suggests the existence of a new critical velocity in addition to the three already well established—the Reynolds, Kennedy, and Woodward. It is apparent that this new critical velocity suggested is not identical with the upper Reynolds' critical velocity, although the fact is not made clear in the text. The author, however, fails to point out one important bearing of the Reynolds' critical velocity on current meter stream gaging. When a stream rises gradually laminar flow persists up to a certain stage. If, now, the stream falls from some higher stage, turbulent flow may persist to a considerably lower stage than that at which the change from laminar to turbulent flow took place when the stream was rising. Thus there may be two different stages with the same discharge in the Reynolds' critical region.

There is another point which the author and other writers on the subject seem never to have mentioned, if indeed they have noticed it. When the Woodward critical velocity is reached, a section of a stream above a given control can, under certain circumstances, flow in equilibrium at two different stages. Which of these stages it will take in a given instance depends on circumstances largely independent of the control. If the stream reaches the given stage from a lower antecedent stage, one of the two alternative flow levels may persist over a considerable range, while the other is likely to persist over a part of the same range if the given stage is reached from a higher antecedent stage. This is entirely independent of the variation in stage for a given discharge resulting from the operation of Reynolds' law, as already pointed out, and is also independent of variation in the control itself, which is here assumed to be permanent. Current meter rating curves for some streams show a tendency for "sport" points to occur and recur at about a certain stage, usually a medium high stage not far from that corresponding to Woodward's critical velocity. This may sometimes be due to alternative stages for the same discharge and not to errors of the measurements, as usually assumed.

Another cause of variations is the fact that the slope at a given stage is greater when the stream is rising than when it is receding, although this may not be of much importance except in certain cases.

Kennedy's formula for the critical velocity in relation to the deposit of silt is given in its original form, without mention of the recent researches in relation to silt deposition and the probable necessary modification of the Kennedy formula, particularly when applied to rivers. The author does not mention the fact, demonstrated by A. B. Buckley (*Proc. Inst. C. E.*, 1923) that the velocity and consequently the discharge of a stream at a given stage varies to an appreciable degree with the amount of silt carried in suspension. In the case of the Nile this variation has been expressed in a definite formula for velocity by S. Lelyavsky, known as the Beleida formula.

A subsequent chapter treats of distribution of velocity in open channels. The theoretical treatment is based on laminar flow, whereas in the majority of cases, for certain stages at least, the motion of water past a current meter gaging station is decidedly turbulent. Some data are given showing the relation of velocity at various points to the mean velocity in a vertical line. Many of these data are comparatively old. There is an enormous amount of excellent data on this subject now available and as yet unanalyzed. It is to be regretted that the author has not presented more of these recent data.

The importance of adequate control for current meter stations is emphasized and the manner in which the control may shift downstream as the stream stage increases is pointed out. An illustration is given showing how, as a result of this, a change in the character of the rating curve may take place, the curve under certain conditions becoming concave upward near the stage for which the control changes position. This refutes the

hitherto commonly accepted dogma that a current meter station rating curve is always convex upward.

The book contains in summary form the results of various investigations of the accuracy and errors of current meters, including the effect of turbulence, though without mention of the recent and important English discussion of this subject by M. A. Hogan, based on investigations at the National Physical Laboratory of England. ("River Gaging," by M. A. Hogan, Ph.D., Department of Scientific and Industrial Research, London, 1925.) No very definite conclusions are reached as to the effect of turbulence, particularly the numerical corrections required to allow for turbulence in the operation of current meters. Current meters are and must often be used in turbulent water, and excellent results can be obtained with proper methods and precautions. A thoroughgoing study of the existing data as to the effect of turbulence on different types of meters is, however, needed to determine the best conditions of operation and the proper corrections to be made.

The author points out that the current meter is not fool-proof and says: "Where the flow is turbulent the meter is called upon to do what it was not designed to do." It seems certain that the inherent defects of the current meter as a device for stream gaging are of less serious import than the defects of the current meter method of stream gaging. The latter include: (1) Concealed errors due to shifting controls. (2) Inapplicability of station rating curves to frozen streams, with the resultant necessity of "estimating" or doing without records for two or three winter months at the majority of northern current meter stations. (3) The failure in many cases to secure accurate results at such stations either for extremely low flows or for flood peaks, the two conditions of a stream in which the engineer is often most interested. (4) Variations of discharge at a given stage even with permanent control and accurate measurements, due to causes already mentioned.

Streams at flood peak stages often carry floating débris, ice or both. The water is frequently both turbid and turbulent and reliable current meter measurement is difficult. Again, the stream stage often changes rapidly near the flood crest. The district engineer who has, say, fifty stations under his charge, with all the streams in flood at once, has small chance of developing station rating curves to their upper limits and broad extrapolations are often made. Such extrapolations may be practically correct but under certain conditions they may be invalidated by a variety of causes, including unknown change of control, a secondary control coming into operation and changing the slope of the rating curve, disturbed control due to lateral inflow, and possible change in the law of discharge above the critical velocity suggested by the author, or above another critical velocity possibly dependent on rolling transport of stream bed materials, as recently demonstrated in the case of the Rhine by M. Strickler ("Beiträge zur Frage der Geschwindigkeitsformeln und der Rauhigkeitszahlen für Ströme, Kanale und Geschlossene Leitungen"; Berne, 1923.) If the law of discharge in relation to slope determined for lower stages does not hold at the highest stages, it is evident that extrapolation of a rating curve from measurements at lower stages may lead to erroneous results.

The discussion of gages of various types—both staff and recording, selection of sites for gages and methods of erecting gages, is excellent and of wide applicability. References to original sources of information are not always complete. For example, the enameled steel sectional gage developed by the reviewer and referred to on p. 61 was first described in *Engineering News*, Aug. 22, 1907, p. 207.

The text gives both the Chezy-Kutter and Manning slope formulas, but the theory given for mean velocity curves in open channels is based on the Chezy formula. This is unfortunate since a constant value of Chezy's "*C*" is assumed (if there is no change in roughness) which does not hold in practice, since the velocity varies nearly as $R^{2/3}$, not as $\sqrt{R}$, as by the Chezy formula. A similar analysis based on the Manning formula is equally simple and considerably more accurate.

In the chapter on Ice Conditions considerable material is drawn from Water Supply Paper No. 187, prepared by H. K. Barrows and the reviewer more than twenty years ago. Here again a vast fund of later material exists unanalyzed. Little detail is given relative to actual methods of arriving at stream flow under ice cover. There is room for intensive study of this subject, particularly as ice obstruction appears to be closely related to the cumulative temperature deficiency below 32 deg. Fahrenheit.

In spite of the fact that the book falls considerably short of a thoroughgoing up-to-date treatment of stream gaging by the current meter method, nevertheless it is distinctly the best book available on the main subject matter covered and will be found useful by those having occasion to maintain or use current meter gagings. It is to be hoped that the book will be expanded in future editions to cover various points in greater detail and include recent developments not treated in the present book.

Socialism Through the Ages

A HISTORY OF SOCIALIST THOUGHT—By Harry W. Laidler, Ph.D., Executive Director, League for Industrial Democracy; Author of "Socialism in Thought and Action," "Boycotts and the Labor Struggle," etc. [Crowell's Social Science Series, Edited by Sera Eldridge, Department of Sociology, University of Kansas.] New York: Thomas Y. Crowell Co. Cloth; 6x8 in.; pp. 713; frontispiece and 13 other portraits. $3.50 net.

Whatever one's attitude toward socialism may be, it is well to make a survey of its theory and attempted practice from the earliest times to the present day. This is particularly desirable for those who feel that they must resist socialism, or at least those of its tendencies that seem to them to be particularly dangerous. Mr. Laidler's History of Socialist Thought is a model of condensation and readableness. It is all the more commendable because it is colored as little as could reasonably be expected by whatever views on the subject the author himself may have. At the same time, the author is sufficiently sympathetic with the men and proposed measures which he reviews to prevent dullness.

The author goes as far as could be expected in summarizing the attitude of every exponent of socialist thought from Amos, Isaiah, Jesus, Plato, to Sir Thomas More and on to Marx, Lasalle, Webb, Shaw, Lenin and Trotsky, the Webbs and the Americans, Hillquit and Veblen, the latter being cited particularly as to "financiers vs. engineers." The various chapters are grouped under Utopian Socialism and Its Precursors; Marxian Socialism; Other Socialist Schools, including Syndicalism and Guild Socialism, Post-War Socialist Developments and Allied Movements, the latter covering the Christian

Socialism of Maurice Kingsley and Thomas Hughes. Comprehensive and timely are the chapters on socialism in Russia before and after the Bolshevik revolution. Various co-operative movements are given attention. The attitude of labor unions to socialism is not overlooked.

Among the many significant suggestions brought out by the book is the doctrine of these socialists who welcome the growing centralization of capital and industry as the easiest possible means of shifting to socialism. The difficulties involved in making the change have been more and more appreciated of late as well as the need for "technicians" and men trained in business and finance, and of the community of interest of all who work, whether by hand or brain. The concluding chapters show a rapid growth of socialists in total numbers and in the parliaments of many of the leading countries of the world and at the same time a growth of tolerance and of wider brotherhood among socialists—unless it be in Russia and, for quite different reasons, in Italy.

Publications Received

HISTORY OF THE INCANDESCENT LAMP is the title of a 208-p. book by John W. Howell and Henry Schroeder, published by the Maqua Co., Schenectady, N. Y. The book, beginning with Edison's invention about 1880, portrays by text and illustrations the changes and developments which have brought the incandescent lamp to its present efficiency.

TWO SHILLINGS is the price of the seventh Interim Report of the Institution of Civil Engineers Committee on Deterioration of Structures of Timber, Metal and Concrete Exposed to the Action of Sea-water. The topics covered are iron, steel, timber blocks, rafts and tests on foreign timbers when treated and creosoted (2 s. from H.M. Stationery Office, London, W.C.2).

MILK-BORNE OUTBREAKS of typhoid and other intestinal diseases, septic sore throat, scarlet fever, diphtheria, and miscellaneous diseases are discussed by Charles Armstrong and Thomas Parran, Jr., Surgeons, U. S. Public Health Service, in Supplement 62, to Public Health Reports (15 c., Supt. of Documents, Washington, D. C.). A total of 612 outbreaks is included as having occurred since an earlier report by the same authors, coming down to the close of 1907 and including 179 outbreaks.

RAILWAYS AND THE MISSISSIPPI FLOOD form the subject of a 96-p. report by a special committee of the American Railway Engineering Association, 431 So. Dearborn St., Chicago, (Bull. 297, July, 1927; $1.00). Besides a review of flood conditions the subjects include protective measures, levee breaks, damage to railways, and the extensive rescue and relief work carried on, all this information consisting of reports or statements from the various railroads concerned. The report closes appropriately with the address on river control delivered before the Flood Control Congress by Major General Jadwin, chief of engineers, U. S. Army.

OPPORTUNITIES FOR IRRIGATION IN KENYA, a British colony and protectorate in Africa, south of Abyssinia, are small, but central water supplies for stock might be provided on a small scale, according to an interesting report by A. D. Lewis, director of irrigation of South Africa, who was loaned to the acting-governor of Kenya "to explore the possibility of irrigation schemes." Mr. Lewis, who is a member of the Institution of Civil Engineers, wrote a report on the subjects already mentioned, and on water law which fills 99 pp., folio, and is accompanied by large folding maps. Most of Kenya has a scanty rainfall. Where rain is relatively abundant the topography is unfavorable to storage. Other local conditions militate against irrigation which, it appears, would be used chiefly to promote sugar and sisal production. The report possesses general interest for its information regarding the water resources, industries and people of a little known part of the world. (5 shillings, from The Crown Agents for the Colonies, 4 Millbank, London, SW.1. England.)

New Books and Revised Editions

[Those desiring copies of the books listed below or mentioned elsewhere in this section should order them from the publishers or from their local booksellers.]

AMERICAN LUBRICANTS: FROM THE STANDPOINT OF THE CONSUMER—By L. E. Lockhart, Consulting and Analytical Chemist. Third edition. Easton, Pa.: The Chemical Publishing Company. Cloth; 6x9 in.; pp. 408; illustrated. $5.

The preface does not indicate the extent of the changes made in this edition but the text shows material dated 1927.

THE DISPOSAL OF THE SEWAGE OF THE SANITARY DISTRICT OF CHICAGO—A Report [dated April 16, 1925] to the District Engineer, U. S. Engineers Office, Chicago, by Alvord, Burdick & Howson, Engineers [Chicago]. Bull. 23, Illinois State Water Survey. Cloth; 6x9 in.; pp. 195; illustrated. Address Illinois State Water Survey, Urbana, Ill.

FINANCIAL STATISTICS OF STATES, 1926—Compiled by Census Bureau. Paper; 6x9 in.; pp. 133. 30c. from Superintendent of Documents, Washington, D. C.

Covers 48 states. Gives total and per capita receipts and expenditures, indebtedness, assessed valuations and tax levies; also total value of state properties.

MACHINE DESIGN DRAWING ROOM PROBLEMS—By C. D. Albert, M.E., M. Am. Soc. M.E.; Professor of Machine Design, Cornell University. Second edition. New York: John Wiley & Son. London: Chapman & Hall. Cloth; 6x9 in.; pp. 355, illustrated. $3.50.

In this edition a chapter of 35 pp. on the design of the mechanical features of a jib crane has been added. There are 18 new tables and 11 have been revised. Minor additions and changes have also been made.

OUR TRAFFIC PROBLEM—By Clifton R. Bechtel, Chairman, Committee on Zoning. Chicago Real Estate Board. Thin pamphlet. Send 2c. stamp to Municipal Reference Library, Chicago, Ill.

RAILWAY STATISTICS, 1926—Compiled by Slason Thompson, Bureau of Railway News & Statistics, Chicago, Ill. Paper; 6x9 in.; pp. 143.

Twenty-fourth year of a well-known compilation, chiefly of American figures, with text relating to the statistics and other matters, written from a railway viewpoint.

REGULATION OF ELEVATION AND DISCHARGE OF THE GREAT LAKES: Designs for Gates, Sluices, Locks, in Niagara and St. Clair Rivers—By John R. Freeman, Civil Engineer. Dec. 30, 1925; Revised to Oct. 1, 1926. (Expansion by Mr. Freeman of his brief preliminary report as a member of the Engineering Board of Review, Sanitary District of Chicago; the board as a whole having been discharged and dismembered on March 28, 1925.) Providence, R. I.: John R. Freeman (Grosvenor Building, Providence, R. I.) Or: For copies address Trustees, Chicago Sanitary District, Chicago, Ill. Cloth; 6x9 in.; pp. 548; many line drawings and insert charts.

REINFORCED CONCRETE CONSTRUCTION, VOLUME II: Retaining Walls and Buildings—Prepared in the Extension Division of the University of Wisconsin by George A. Hool, S.B., Professor of Structural Engineering, University of Wisconsin. Second Edition. [Engineering Education Series.] New York and London: McGraw-Hill Book Co., Inc. Cloth; 6x9 in.; pp. 690; 411 halftones and line cuts, 18 insert plates, many charts and tables. $6.

As compared with the first edition, much of the material has been completely rewritten so as to bring it up to date and to make it conform in general to the recommendations in the 1924 Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete. Attention is especially called to the chapters on the design of flat slab floors, eccentric load conditions in columns, elevators and elevator shafts, wind stresses, earthquake stresses, and estimating, which contain much new material.

RESIDENTIAL SEWAGE TREATMENT PLANTS—By Lyndon J. Murphy, Municipal Engineer, Engineering Extension Department, Iowa State College, Ames, Iowa. Illustrated pamphlet.

RUDIMENTS OF ECONOMICS—By William Wallace Hewitt, Ph.D., Assistant Professor of Economics, University of Pennsylvania. New York: Thomas Y. Crowell Co. Cloth; 5x8 in.; pp. 247. $1.75.

A brief and readable college textbook with bibliographical references to other works on the subject.

A STUDY OF THE POLLUTION and Natural Purification of the Illinois River: I. Surveys and Laboratory Studies—By J. K. Hoskins, Sanitary Engineer, C. C. Ruchoft, Junior Chemist, and L. G. Williams, Junior Assistant Sanitary Engineer. [Public Health Bull. 171, U. S. Public Health Service.] Paper; 6x9 in.; pp. 208; illustrated. 50c. from Superintendent of Documents, Washington, D. C.

The river is some 300 miles long, and receives the discharge of the Chicago Drainage Canal.

TRADE AGREEMENTS, 1926—Compiled by Bureau of Labor Statistics, U. S. Department of Labor. Paper; 6x9 in.; pp. 204. 30c. from Superintendent of Documents, Washington, D. C.

U. S. GOVERNMENT MASTER SPECIFICATION for Tile, Hollow, Clay Floors—Thin pamphlet. 5c. from Superintendent of Documents, Washington, D. C.

News of the Week

Current Events in the Civil Engineering and Contracting Fields

Am. Soc. C.E. to Aid Flood Control Work On Mississippi River

Board of Direction Authorizes Special Committee—Lincoln Bush Is Presidential Nominee

ALL but one of the members of the Board of Direction of the American Society of Civil Engineers attended a meeting held in Columbus, Ohio, Oct. 10, preceding the fall meeting of the society. During its session the board acted upon 357 applications for admission and transfer. Meeting as a nominating committee on Oct. 8 the directors named Lincoln Bush, of East Orange, N. J., as the official nominee for president of the society during 1928.

The board elected to honorary membership in the society Charles D. Marx, past-president of the society and professor-emeritus of civil engineering at Stanford University.

The Mississippi River flood-control problem was discussed at length by the board, and the president was authorized to appoint a committee of five specially qualified engineers under his chairmanship, whose services should be available for whatever contribution toward the solution of the problem might seem to be appropriate on the part of the society. Appropriation of funds was made for the use of the committee.

At the suggestion of a number of members of the society the board authorized representations to be made wherever advisable toward the appointment of an engineer upon the Interstate Commerce Commission.

MEDAL AWARDS ANNOUNCED

The Norman medal was awarded to B. F. Jakobsen for his paper "Stresses in Thick Arches of Dams." The J. James R. Croes medal was awarded to H. C. Ripley for his paper on "The Relation of Depth to Curvature of Channels." The Thomas Fitch Rowland prize was awarded to L. S. Stiles for his paper on "Pipe Tunnel Under Gowanus Canal, Brooklyn, N. Y."; the James Laurie prize to John R. Baylis, for his paper on the "Corrosion of Concrete"; the Arthur M. Wellington prize to John A. Miller, Jr., for his paper on "Increasing the Efficiency of Passenger Transportation in City Streets"; and the Collingwood prize for junior members of the society to William Breuer for his paper on "Trend of Construction Cost of Certain Public Utilities."

Charles R. Gow, Arthur N. Talbot and Allen Hazen, as a subcommittee of the Research Committee, submitted a report on the basis of which the board authorized and outlined the scope of a special committee which is to study the physical properties and behavior of soils under the application of structural loads and to recommend a procedure in the treatment of foundation problems.

Based upon a comprehensive report from the committee on local sections policies were laid down and measures approved looking toward the development of a more stimulating contact between the local sections and the society.

The board considered several cases involving alleged unprofessional conduct brought to its attention through a report of the committee on Professional Conduct.

Approval was given to a recommendation of the executive committee that the society join the International Federation for Housing and Town Planning. An additional appropriation of funds was made for the work of the special com-

(*Continued on p. 650*)

Hudson River Bridge to Be of Wire Cable Design

The Port of New York Authority on Oct. 12 awarded to John A. Roebling Sons Co., Trenton, N. J., contract for the erection of the cables for the Hudson River Bridge. At the same time the contract for the steel towers and floors was given to McClintic-Marshall Co. The Roebling and McClintic-Marshall bids total $22,474,417, or about $200,000 under the next lowest combined set of figures. The cable bid alone was $12,339,977, and the McClintic-Marshall bid, $10,134,440.

The other bidders on this project were named in *Engineering News-Record*, Oct. 6, p. 563, and an analysis of the combination bids in *Engineering News-Record*, Oct. 13, p. 592.

Herminghaus Water Case Fails to Get Federal Hearing

Appeal from the decision of California courts in the Herminghaus case will not be heard by the Supreme Court of the United States, according to Washington dispatches which announce that the Federal Court has ruled that it has no jurisdiction in the matter.

The appeal was entered by the Southern California Edison Co. in an endeavor to set aside rulings of the California courts that granted the Herminghaus estate an injunction estopping the Edison company from storing flood waters of the San Joaquin River for power purposes.

The gist of the decision handed down by the California court, and editorial comment thereon were contained in *Engineering News-Record*, Feb. 3, 1927, pp. 181 and 204.

Flood Control on Program of U. S. Commerce Chamber

Tax Reduction, New Civic Objective for Business Also Discussed at West Baden Session

(Engineering News-Record Staff Report)

PURSUANT to a new plan, about 400 members of the U. S. Chamber of Commerce met at West Baden, Ind., over last weekend for a four-day meeting, packed with the sessions of committees, councillors and members of the board of directors. The sessions closed Oct. 18. Of first importance were reports on Mississippi flood control, tax reduction and a new civic objective for business. Additional subjects covered in general meetings were a project for getting out the vote at elections, reduction of postal rates, maintenance of the integrity of the Federal Reserve System, self-regulation by business, the part played by member organizations in legislation and the relation of these organizations to the public and the press. Twenty different committees held meetings, reviewed the progress of their work, and, where advisable, laid out new plans. As always at U. S. Chamber of Commerce meetings the attendance included a large number of the leaders of American business, both from industry and trade. General judgment was that this new plan of grouped committee and national councillors meetings was a success, enabling all groups sharing in the chamber's work to advance materially their activities.

FLOOD CONTROL RECOMMENDATIONS

Mississippi flood control was presented through addresses by Lewis E. Pierson, president of the chamber, John M. Parker, former governor of Louisiana, and through a report of the chamber's flood committee headed by Frederic A. Delano, as chairman. The report was ordered to be made the basis for referendum to chamber members. It recommends "(1) that the federal government should hereafter pay the entire cost of constructing and maintaining the works necessary to control the floods of the lower Mississippi, that is from Cairo to the Gulf, (2) that the federal government should assume the sole responsibility for locating, constructing and maintaining such works, (3) that there should be an adequate appropriation to insure efficient, continuous and economic work, the funds to be made available as needed, (4) that flood control on the Mississippi is a work of such magnitude and urgency that it

(*Continued on p. 651*)

N. Y. State Commission Approves First Stage of Water Plans for Albany

The plans for an additional water supply for the city of Albany, N. Y., recommended about a year ago by Robert E. Horton, consulting engineer, Voorheesville, N. Y. (see *Engineering News-Record*, Sept. 23, 1926, p. 520) have been approved, with some modifications, by the New York State Water Power and Control Commission. Mr. Horton's recommendations were for a supply to be taken in three stages from Hannacrois, Basic and Catskill Creeks by gravity conduits leading from a series of storage reservoirs. Provision for ultimate filtration was made but was not included in the recommendation for early construction. The state commission mentioned has approved the first stage, but requires that steps be taken for immediate filtration.

First-Stage Plan

Under the plan as approved for the first stage of construction, a 4,400-m.g. reservoir would be built on Hannacrois Creek near Alcove, being formed by a dam 59-ft. high flooding 730 acres. From this reservoir water would be discharged into an aeration basin and then, under the addition required by the state commission, through a mechanical filtration plant and thence through a 40-m.g.d. conduit about 20 miles long, leading to a new distribution reservoir in Albany with a capacity of about 100 m.g. It is expected that the conduit will be 45 in. in diameter and will be constructed of steel with cement mortar lining.

There will also be constructed an additional 8,000-m.g. reservoir on Hannacrois Creek, this being formed by a 74-ft. dam at Indian Fields, flooding 850 acres. Both these dams would be of earth, with core walls, and with a masonry overflow spillway. A third reservoir contemplated in the first stage of construction would be provided on Basic Creek and water from it diverted by a 2,200-ft. tunnel into Indian Fields reservoir.

The combined drainage area tributary to the three reservoirs mentioned will be about 50 sq.mi., nearly all of which drains into Indian Fields and Basic Creek reservoirs, from which the water can be discharged into Alcove reservoir or fed directly to the filters and to the city distribution reservoir at Albany. Including improvements to the city distribution system the estimated cost of the first stage, as originally proposed by Mr. Horton, was $8,400,000, to which some $800,000 to $1,200,000 will be added by the filtration plant required by the state commission.

Associated with Mr. Horton in investigations on this project carried on since the report of a year ago, has been the firm of Whitman, Requardt & Smith of Baltimore; also, for supplementary hydraulic studies, H. K. Barrows, consulting engineer of Boston. The main features of the project were also checked by Fuller & McClintock.

War Department Disapproves San Francisco Bay Bridge

After careful consideration of the request presented by the delegations from the Board of Supervisors of the City and County of San Francisco, San Francisco, California, that authority be given for the construction of a bridge over San Francisco Bay, the Secretary of War has notified the chairman of the delegations that plans for a bridge north of the Hunters Point-Alameda line will not meet with War Department approval. The War Department press release says:

Extensive growth is expected on the Pacific Coast and the country tributary thereto. The number of potentially great harbors on the Pacific Coast is limited and the distances between them are large. San Francisco must be looked on therefore as a potentially great national harbor.

Any doubt as to whether a bridge would interfere with the proper development of navigation in this port, should be resolved in favor of the national interest of navigation rather than the advantage to local highway traffic. The Department is ready to further any improvement in communications which will not conflict with the major duty of preserving the navigable capacity of San Francisco Bay for the future needs of the nation.

Plans are under way in San Francisco to go before Congress in December to urge that body to take the bridge question out of War Department jurisdiction.

San Francisco Will Vote On Bay Bridge Question At Election November 8

The question of whether the proposed bridge across the bay between San Francisco and Oakland, Calif., should be built by public or by private funds will be submitted to the voters of San Francisco at the Nov. 8 election. It is proposed to submit to the voters two propositions, each one framed by interests supporting different points of view. The first proposal will be essentially as follows: "That the public interests will be best served if the proposed transbay bridge * * * is financed, constructed, held and operated under public ownership." The other proposal includes the statement that "it should be the policy of the board of supervisors to favor a publicly owned bridge from San Francisco to Alameda County but in the interest of getting immediate construction of this bridge, approval should be given to a project financed by private capital with provision whereby the people might later, as established by law, take over the bridge and place it under public ownership and control."

Proponents of the plan for privately financing the bridge point out that San Francisco is now so close to the limit of bonded indebtedness that bridge bonds could not be voted until legislative action removed such an enterprise from the bond limitation. This legislative sanction would mean a delay of approximately two years.

Miller Decries Withdrawal of Building Trades From Jurisdictional Award Board

Fear that many millions of dollars will be wasted in the building industry, as a result of the withdrawal from the National Board of Jurisdictional Awards at Los Angeles on Oct. 3 of the Building Trades Department of the American Federation of Labor, is expressed by Rudolph P. Miller of New York, Chairman of the Board, on which he represents the American Engineering Council.

"Unless the building trade labor unions can immediately start the operation of some new plan for the settlement of jurisdictional disputes," says Mr. Miller in a statement issued through the American Engineering Council, "the situation, which has been fairly well controlled for the past few years, will revert quickly to the chaotic conditions of former times. This action by the Building Trades Department almost automatically dissolves the National Board.

"It is a real misfortune that this Board must be dissolved, for there is no doubt in my mind that, in the eight years of its existence, it has saved millions of dollars that would otherwise have been wasted in settling strikes caused by jurisdictional disputes. Contractors have told me that the elimination of these strikes has saved hundreds of thousands on single contracts. And the members of the labor unions have been saved an untold amount in wages otherwise lost during strikes."

Cause of Withdrawal

Disputing the reasons given in the resolution which announced the withdrawal of the Building Trades Department, Mr. Miller asserted that the real cause of the action was simply that their representatives were not willing to abide by the rulings laid down unless they were wholly in accord with their own demands.

In reply to the attacks made by labor leaders upon him personally, in which it was declared that he was dictatorial and unfair in his decisions as chairman of the Board, Mr. Miller pointed out that his office of chairman gave him no special prerogatives.

"Very few of the men really feel, I think, that I have been unfair," Mr. Miller declared. "At least I have offered to resign and they have refused to consider it. The cause for the attacks simply lies in the fact that the delegates must have some reasons to give their electors in case of failure to achieve a point, and the cry of unfair discrimination is always a good one."

Mr. Miller, who was formerly Superintendent of Buildings in Manhattan, declares that any new plan for the settlement of jurisdictional disputes that is introduced must contain the one main point upon which the constitution of the National Board was based. That is, pending the settlement of a dispute, the work must go on without a strike.

Am. Soc. C.E. to Aid Flood Control

(*Continued from p. 648*)

mittee on irrigation hydraulics. A resolution of appreciation and regret was adopted to recognize the services and the death of Thomas J. McMinn, former assistant secretary of the society. The place of the spring meeting for 1929 was fixed as Dallas, Texas.

The society met in a series of sessions Wednesday and Thursday, Oct. 12 and 13. Wednesday morning was devoted to the formal part of the program and to registration. Before the meeting closed, the registration reached almost 650, more members than have attended any fall meeting except that of last year at Philadelphia.

Technical sessions began during the latter part of the morning with the water supply of the city of Columbus as the first topic. It began with a joint paper describing the O'Shaughnessy Dam and reservoir by John H. Gregory, C. B. Hoover, and C. B. Cornell. This paper was followed by one by Charles P. Hoover, the chemist in charge of the water softening and purification works at Columbus, describing the work of his department. The discussion of this paper by F. H. Waring, chief engineer of the Ohio State Department of Health, by George W. Spohr and Robert Spurr Weston of Boston, also Professor Folk of Columbus, emphasized the fact that the Columbus water purification plant has been a pioneer in water softening, especially in the use of carbon dioxide gas in the process.

Session on Flood Control

Wednesday afternoon was given over entirely to a discussion of the Mississippi River flood problem. Details of the discussion will be found on page 636 of this issue. This discussion was carried through Thursday in an all-day session of the Waterways Division. The structural division met on Thursday morning. Its papers are reported on page 639 of this issue. On Thursday afternoon the Highway and Sanitary Engineering Divisions held concurrent sessions. A brief report of the papers before the Highway Division is given on p. 640 of this issue.

Two papers were presented at the Sanitary Engineering Division, one entitled "Sewer and Water Works Construction Under the County Sewer District Law of Ohio and the Assessment of Costs in Proportion to Benefit" by E. G. Bradbury, county sanitary engineer at Columbus, and one entitled "The Sewerage Disposal Works of Decatur, Ill.," by William D. Hatfield, superintendent of the plant, and Samuel A. Greeley, of Chicago.

Dinners for the members and their guests were held both Wednesday and Thursday evenings. At the Wednesday evening meeting Secretary of War Dwight F. Davis spoke on the Mississippi River flood problem, and at the Thursday evening meeting Julius F. Stone, president of the Board of Trustees of Ohio State University, gave an illustrated lecture entitled "The Story of the Stars."

Friday was devoted to an all day excursion to the water purification works, dams and reservoirs of the Columbus water system, also an extension of this trip to see some of the highway construction in the neighborhood of Columbus. For those who remained over Saturday, a trip was arranged to the engineering buildings, laboratories and experiment station of Ohio State University, followed by luncheon at the University and a football game in the afternoon at which time the members were given an opportunity to examine the University stadium, designed to seat 70,000 persons.

California Water-Works Meeting at San Jose Has Record Attendance of 564

Attendance at the eighth annual meeting of the California Section, American Water Works Association, at San Jose, Calif., Oct. 5 to 8, topped the record which the California Section has been advancing each year. Registration for the three preceding conventions was respectively, 197, 247 and 387. This year 564 members and guests attended and there were 52 exhibits. A feature of the San Jose meeting was the presence of Beekman C. Little, Rochester, N. Y., national secretary, who was looking over the field in making plans for the annual meeting of the Association in San Francisco next June.

In accordance with custom, each session of the convention included at least one symposium on which there was a general exchange of ideas. This year there were three: (1) Watershed protection, (2) water main installation methods, dealing with both cast-iron and steel pipe; (3) cross-connection practice. Among the subjects of individual papers were "Removal of Sulphur from Well Water," by Arthur Taylor, consulting engineer, Los Angeles; "Details of Steel Tank Construction," by I. E. Flaa, assistant engineer, Spring Valley Water Co.; and "Centrifugally Cast High-Pressure Pipe Line for the City of Riverside," by Edward R. Bowen, consulting engineer, Los Angeles. One afternoon was devoted to a practical field demonstration of modern water-works practice during which there were made large taps under pressure, a large cement pipe joint, and various tests.

Officers for next year are: Chairman, Joseph R. Ryland, president, San Jose Water Works; Vice-chairman, John Burt, manager, Marin Municipal Water District; Secretary-treasurer, W. W. Hurlbut, office engineer, Los Angeles, Bureau of Water Works and Supply. Next year's annual convention will be held in conjunction with the meeting of the American Water Works Association in San Francisco, beginning June 11.

Colorado River Parley Adjourns Until Nov. 7

On Aug. 22 a seven-state governors' conference on Colorado River problems convened in Denver with six governors present and a seventh coming. The conference was called by state officials of Wyoming, Colorado, Utah and New Mexico, known as the upper-basin states, who acted as hosts to representatives of the lower-basin states, California, Nevada and Arizona. The primary objective was the settlement of points in dispute between California and Arizona although the whole question of control and development of the Colorado River was to be discussed. It was hoped by those who arranged the meeting that it would be possible to reach some common ground and ratify some agreement such as the Santa Fe compact.

There was no lack of discussion, in fact, there were times when the meeting threatened to break up because of it. However, the sessions continued for ten days and then adjourned to Sept. 19. After reconvening with delegates fresh from discussion with officials in their several states the conference labored through another session and on Oct. 4 adjourned until Nov. 7 without having reached any settlement of differences between the lower-basin states.

The discussions centered on allocation of water and power rights, with major differences between California and Arizona. As an indication of the terms on which the apportionment of water was discussed, the upper-basin states suggested an allotment of 4,200,000 acre-ft. to California, 3,000,000 acre-ft. to Arizona and 300,000 acre-ft. to Nevada. This was not acceptable to the lower-basin states; California's ideas to what it should have being as unacceptable to Arizona as Arizona's ideas were to California. In the last day or two of the second session four specific proposals made by Arizona and Nevada of a basis of agreement on a power development plan are reported to have been rejected by California representatives. It is still hoped that the third session, convening Nov. 7, will bring some agreement or compromise that will enable all seven states to combine on a plan.

The Santa Fe compact, it will be remembered, was ratified in 1922 by six states, Arizona alone withholding approval. California later imposed certain restrictions on its ratification and Utah rescinded its ratification altogether.

New Building at Ohio University

At the Ohio State University, Columbus, Ohio, there is under construction a new chemistry building which will be 300 ft. long and four stories high. Its architectural design harmonizes with the engineering quadrangle, of which the civil engineering building and the first part of the engineering experiment station now form a part. A new wing for the civil engineering building has been planned, but is not yet authorized.

Flood-Control on Program of U. S. Commerce Chamber

(*Continued from p. 648*)

should be dealt with in legislation and administration upon its own merits, separate and distinct from any other undertaking." These recommendations were supported by the report with its various appendixes and exhibits.

In tax reduction the chamber is now asking member organizations to vote on a suggestion that the corporation income tax be reduced from 13½ per cent as now to 10 per cent. The chamber's committee, as already announced, asks a total tax reduction of $400,000,000. Reductions advocated include the abolition of the federal inheritance tax and excise taxes imposed as war measures.

The committee on civic development suggested that American business take as its guide in all activities objectives set forth in the preamble to the federal constitution, namely, "to form a more perfect union, establish justice, insure domestic tranquillity, provide for the common defense, promote the general welfare and secure the blessings of liberty for ourselves and our posterity."

The committee on postal service advocated the elimination of the higher rates made effective in 1925 on private mailing cards and circular matter, and also war rates on advertising in magazines and newspapers.

Harry A. Wheeler, president of the Union Trust Co., Chicago, discussed the benefits of the Federal Reserve System and urged strong defense of the system by business.

Judge Edwin B. Parker, chairman of the board of directors of the chamber, advocated regulation of business by itself, asserting that if it does not do so, the government will. He commended the helpful attitude of the Federal Trade Commission in desiring to assist business to work out rules of business conduct in the interest of business itself, but in a manner to safeguard the interests of the general public.

The president, Mr. Pierson, in closing the sessions, pointed out that the national councillors present had a grave responsibility, for on them rested the task of taking back to their organizations the problems studied by the chamber and there creating that informed public opinion which will bring its influence to bear on government for the common welfare.

Injunction Suit Follows Naming Transitman As St. Paul Water Engineer

An unusual situation in the municipal engineering service at St. Paul, Minn., has followed the resignation, in August, of George M. Shepard as chief engineer of the department of public works, to become chief engineer of the Northern States Contracting Co. His successor is John W. Kelsey, formerly general superintendent of the bureau of water, and it was understood that this latter important position would be filled by means of civil-service examination.

A clause in the charter provides that the appointment of a man having peculiar or exceptional qualifications of a scientific character may be made without civil-service examination. However, a transitman in the department of public works, Clyde L. May, was appointed to this position. A group of citizens then served a temporary injunction on the city. This injunction was granted and will come up for a hearing on a permanent injunction probably in December. The injunction stops the city from paying Mr. May's salary, which is approximately $5,000 per year, while as a transitman he was receiving $165 per month.

In the evidence submitted to the judge in the request for an injunction, was an affidavit by the superintendent of construction for the city to the effect that Mr. May had made an error in the alignment of the Belt Line sewer which had cost the city something like $1,000 to correct. A commimttee of the Engineers' Society of St. Paul has made a careful investigation, but has declined to make any report while the matter is pending in court.

Engineer Elected President of Railway Roadmasters

Economic aspects of track maintenance, rather than details of methods of practice, were featured in the reports and discussions at the annual meeting of the Roadmasters and Maintenance of Way Association, held at Buffalo, N. Y., in September. In a paper on "The Economics of Heavy Track Construction" Geo. J. Ray, chief engineer of the Delaware, Lackawanna & Western R.R., pointed out that locomotives now have axle loads of 30 to 35 tons, while on large coal cars these loads reach about 26 tons. Heavy track, in his opinion, involves a wide roadbed, good drainage, deep ballast, plenty of treated ties, large tie-plates, screw spikes and heavy rails. But the heavy rails bring problems in renewals, as a 130-lb. rail worn out on main track is an expensive item to put in side track. Methods of keeping record and account of stocks of track material, in order to avoid excessive investment in stock, were dealt with in a committee report and also in a paper by H. C. Pearce, director of purchases and stores, Chesapeake & Ohio Ry. Other reports included: (1) Education of track men as a means of preventing accidents; (2) use and abuse of motor cars; (3) means of reducing work-train service; (4) collection and use of cost data in track-work; (5) rearrangement of track work to promote the employment of uniform forces throughout the year. As to this last subject, it was pointed out that experience has proved that numerous items of track work can be done economically even in severe weather.

Officers elected for 1927-28 are as follows: President, J. P. Davis, engineer of maintenance-of-way, Central Indiana R.R.; vice-presidents, H. R. Clarke, general inspector of permanent way, Chicago, Burlington & Quincy R.R., and E. E. Crowley, roadmaster, Delaware & Hudson R.R.; secretary (re-elected), T. F. Donahoe, general supervisor, Baltimore & Ohio R.R., Pittsburgh, Pa. The next meeting is to be held in Detroit, Mich.

OLD LOCOMOTIVES OPERATING UNDER THEIR OWN STEAM: B. & O. CENTENNIAL

Engineering Societies

Calendar

Annual Meetings

AMERICAN SOCIETY FOR MUNICIPAL IMPROVEMENTS, St. Louis, Mo.; Annual Meeting, Dallas, Texas, Nov. 14-18, 1927.

ASPHALT PAVING CONFERENCE: Under the auspices of the Asphalt Association and Association of Asphalt Paving Technologists; annual conference Atlanta, Ga., Nov. 28-Dec. 2, 1927.

HIGHWAY RESEARCH BOARD, NATIONAL RESEARCH COUNCIL, Washington, D. C.; Annual meeting, Washington, D. C., Dec. 1 and 2, 1927.

AMERICAN ROAD BUILDERS ASSOCIATION, Washington, D. C.; Annual Convention, Cleveland, Ohio, Jan. 9-14, 1928.

AMERICAN SOCIETY OF CIVIL ENGINEERS, New York City; Annual Meeting, New York City, Jan. 18-20, 1928.

ASSOCIATED GENERAL CONTRACTORS, Washington, D. C.; Annual Convention, West Baden, Ind., Jan. 23-27, 1928.

THE DETROIT, MICH., SECTION OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS and the Detroit Engineering Society at a joint meeting Oct. 14 had two papers on the bearing power of soils, one by W. S. Housel, instructor in civil engineering, University of Michigan, based on experience with the Wayne County Road Commission, and the other by R. L. Morrison, professor of highway engineering and highway transport, University of Michigan.

THE WASHINGTON, D. C., SOCIETY OF ENGINEERS at its regular meeting Oct. 19 had an address, "History of Sanitation," by A. D. Guion, advertising manager, Bridgeport Brass Co.

THE BOSTON SECTION OF THE AMERICAN WELDING SOCIETY will have an illustrated address Oct. 21 on electrical welding on structural steel and ornamental iron, by Paul B. Covey, of the Manchester Engineering & Welding Co., Manchester, N. H.

THE NEW YORK SECTION OF THE AMERICAN WATER WORKS ASSOCIATION will hold its fall meeting on Oct. 27 and 28 at the Powers Hotel, Rochester. A program of general interest to all waterworks men has been arranged. Inspection trips, a luncheon and dinner, as well as entertainment are included on the program.

Personal Notes

DAN B. MILLER, for the past year engineer and secretary of the Western Asphalt Association, is to have charge of the highway building activities of the Union of Socialist Soviet Republics (Russia). His resignation has been accepted by the directorate of the Western Asphalt Association and he is to sail soon for Moscow. The road-building program of Russia contemplates five years, at least, of intensive work, according to plans announced in Los Angeles by envoys of the Soviet government. Mr. Miller expects to make his headquarters for some time at Baku, in southeastern Russia near the Persian border. Before he went to Los Angeles about five years ago, Mr. Miller was maintenance engineer of the Wyoming State Highway Department.

J. R. WEST, former chief engineer of the Port of Seattle who has been in China for eleven years, has returned to this country and has been retained by the Port of Seattle Commission in connection with the new $7,000,000 terminal project which is planned for the north end of the East Water Way in that city. Mr. West went to China in 1916 to become a professor of civil engineering at the Chinese Government University at Tientsin, remaining in that position for three years. He then became chief engineer of the Min River Conservancy at Foochow, continuing this work until the Chinese uprising brought it to a sudden end. Mr. West will not return to China.

BERNARD L. CROZIER, who was in 1925 appointed chief engineer and head of the department of public works, as well as a member of the board of estimate of the city of Baltimore, and who continued in that work until the recent changes in the department, has opened an office as consulting engineer at 1312 Court Square Building, Baltimore. Mr. Crozier's service in municipal engineering in Baltimore comprises six years as assistant engineer and four years as office engineer in charge, Baltimore Paving Commission, and three years as highways engineer for the city, together with his three years as chief engineer of the city, as noted above.

W. H. CORDDRY, formerly general manager of the Louisiana Public Utilities, one of the companies operated by Gannett, Seelye & Fleming, Inc., has been made manager of the utility operating department of Gannett, Seelye & Fleming, Inc., and is now located in the main office at Harrisburg, Pa.

CLIFFORD M. SWAN announces the severance of his connection with the Johns-Manville Corporation in order to devote himself exclusively to his consulting practice in the field of architectural acoustics, with an office at 271 Madison Ave., New York City. Mr. Swan is a licensed professional engineer in the state of New York and a graduate of both Massachusetts Institute of Technology and Harvard University.

HANS W. JORGENSEN, long an attaché of the city engineer's office, has been appointed city engineer of San Diego, Calif., and Robert M. Gregory, formerly in charge of a field party, has been appointed superintendent of streets. For some years the three offices of city engineer and superintendent of streets and manager of operations in San Diego have been combined under one official, but the rapid growth of the city has made this combination inadvisable and the city council has relieved F. M. Lockwood, who had held all three titles, of the first two and has continued him as manager of operations.

COLLINS P. BLISS, associate dean of the college of engineering and head of the department of mechanical engineering of New York University, has been appointed consulting engineer of the U. S. Bureau of Standards at Washington, D. C., and in this capacity he will represent the Department of Commerce on the Federal Specifications Board. In 1926 Professor Bliss was made chairman of the Standardization Committee of the American Society of Mechanical Engineers, and he has also been the representative of that society on the executive committee of the American Engineering Standards Committee.

MAJOR MALCOLM ELLIOTT, Corps of Engineers, district engineer at New Orleans, La., has been ordered to Juneau, Alaska, for duty as president of the Board of Road Commissioners of Alaska, vice Major Douglas H. Gillette, Corps of Engineers, who has been assigned to another station.

J. L. HOLST, formerly designing engineer of the Detroit River Tunnel, engineer of structures in the electric zone of the New York Central R.R., and lately chief engineer of the Todd, Robertson, Todd Engineering Corporation, has opened an office at 420 Lexington Ave., New York City, as consulting engineer for the construction of buildings, bridges, tunnels, and marine structures.

Obituary

MERLE W. ROSENCRANS, assistant bridge engineer for the Oregon State Highway Commission, died Oct. 9 at his home in Salem, Ore., aged 38 years. Mr. Rosencrans was born in Ruthven, Iowa, and graduated in civil engineering from Iowa State College in 1912. The next year he went to Portland, Ore., as partner to C. W. Woodruff consulting engineer. In 1918 he was appointed professor of civil engineering at Oregon Agricultural College, and the following year, 1919, assistant bridge engineer for the state highway commission.

JAMES M. NOLAN, superintendent of buildings, Albany, N. Y., since 1922, died Oct. 11 at his home in Albany, at the age of 64 years. Prior to his five years' service with the city, Mr. Nolan had been for many years superintendent of construction for John Dyer, Jr., building contractor in Albany.

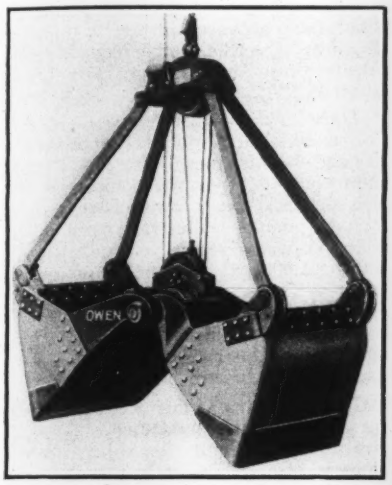
WILLIAM G. A. MACDONALD, for several years an engineer with the city of Montreal and active in the laying out of the city's sewage system, died at his home in Montreal on Oct. 10, in his 76th year. Mr. MacDonald was formerly employed by the engineering department of the Canadian Pacific Ry. as a bridge engineer.

Construction Equipment and Materials

A Section Devoted to What the Manufacturer Is Doing for the Engineer and Contractor

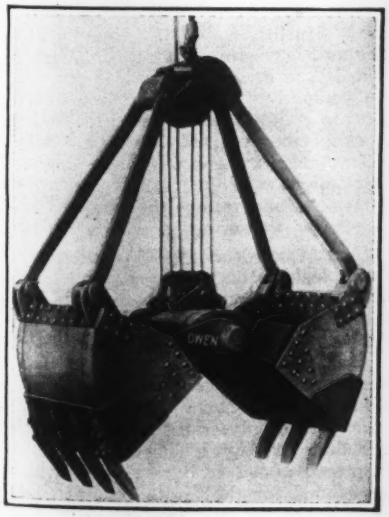
Two New Clamshell Buckets Show One-Piece Crosshead

Two new models, type "M," a digging bucket, and type "K," a rehandling bucket, have been recently announced by the Owen Bucket Co., Cleveland,



Ohio, as replacing its older type models known as "O" and "J". Type "M" shown in the upper illustration is made in three models—standard, special, and narrow, and type "K" shown below is made in three models—standard, special, and the high speed; the illustration shows the high speed model in which there is an exceptionally sharp pitch to the bottom plates to aid in rapid handling of the materials.

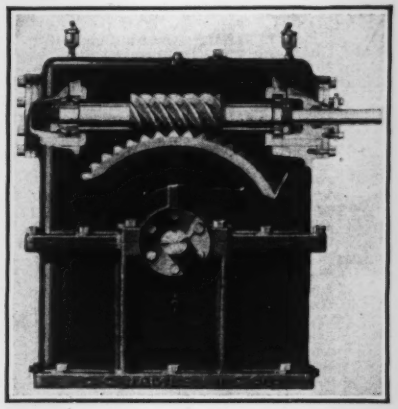
A new design of crosshead in one



piece having 17 less parts than on any previous type of Owen bucket is an important feature and makes it possible to shorten the arms and to provide for operation in reduced headroom. Provision is also made for complete protection and lubrication of the main or center shaft bearing which has double the bearing area of the older types. Extra heavy special alloy steel lips extending up the side plates past the wearing point are used. In addition, the elimination of extra thickness of angles at the corners of the cutting edges insures deeper penetration and larger grab.

Worm Gear Speed Reducer Built for Long Life

In the new heavy-duty worm gear speed reducer, announced by the D. O. James Mfg. Co., Chicago, there are, used phosphor bronze gears, chrome nickel steel worms, Timken and Norma



Hoffman roller bearings, interchangeable bushings, 0.4 carbon steel gear shafts and gray iron housings.

The large oil cooling chamber prevents overheating, and an oil level cock fitted into the side of the housing guards against over-oiling, a condition just as serious as under-oiling. A large heat radiating and oil cooling space in the housing keeps the oil at a low, even temperature. The easily repacked stuffing gland on the worm shaft prevents oil leakage.

Electric Motors Designed for Drilling And Pumping Oil Wells

A special double rated induction motor for drilling and pumping oil wells has been developed by Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. It is a variable speed motor of the wound rotor type, and is designed to run at 575 r.p.m. on the low rating and 1160 r.p.m. on the high rating. The control equipment, consisting of a drum controller, a pole changer, an oil circuit breaker, and a grid resistor, is assembled as a complete self-contained unit. Two of these new motors belted to a common countershaft provide an efficient twin-motor drilling outfit which is claimed to be particularly applicable to cable tool drilling. The power varies from 15 to 30 hp. at comparatively low speeds whereas in handling casing, tools, etc., the power requirements are from 50 to 75 hp. with overloads of perhaps 150 hp. at intermittent periods. The two motor outfit provides the necessary motion for the drilling operation, and also provides the necessary intermittently high torques required to handle casing, tools, etc. In the operation of the equipment, both motors are operated on their low speed connections for drilling and on their high connections for hoisting the drilling tools and running the bailer.

Business Notes

BELLE CITY MFG. CO., Racine, Wis., manufacturer of crawler attachments for Fordson tractors, announces new officers and a plan for an increase in production, at the same time bringing out several new lines of equipment. The new officers are H. A. Reed, president and general manager; W. J. Tostevin, vice-president; G. A. Nelson, secretary-treasurer; H. A. Schultz, assistant secretary and assistant treasurer.

NATIONAL STEEL FABRIC CO., Pittsburgh, Pa., announces that Robert L. Glose, formerly sales agent for the company, has been made sales manager, and that Charles C. Mercer, formerly sales counsel, is made advertising manager.

AIR REDUCTION CO., INC., New York City, has purchased the oxygen plant, equipment and business of the New England Compressed Gas Co., Boston. With this new purchase, the company now has command of the production and distribution facilities of 35 oxygen plants located in or near large industrial centers of the United States.

MASSILLON POWER SHOVEL CO., Massillon, Ohio, announces that its New York representatives are now W. D. Neuberg and W. C. Ewing, with offices at 225 Broadway.

CHAS. E. SHEARER, for several years advertising manager, Industrial Works, Bay City, Mich., has resigned, effective Oct. 20. No announcement has yet been made as to his future connection.

H. D. CONKEY & CO., Mendota, Ill., manufacturers of cranes, hand hoists, wheelbarrows, and similar equipment, announces that changes have been made in its territorial representatives, and that these representatives are now as follows: W. C. Minier, Leader-News

Building, Cleveland, Ohio; Chatard & Norris, 206 Water St., Baltimore, Md.; and the American Engineering Co., Oliver Building, Pittsburgh, Pa.

New Publications

Steam Turbines—DEAN HILL PUMP Co., Anderson, Ind., has issued Bulletin No. 1202 describing its Wait type steam turbines. Details of construction are illustrated and several pages of the bulletin are devoted to a description of methods for determining water rates and the correction factors due to superheat and back pressure for the turbines.

Centrifugal Pumps — LABOUR Co., Chicago Heights, Ill., has devoted a new bulletin No. 29 to its centrifugal self-priming pumps. The principle of operation and details of construction are explained and illustrated.

Chlorinators — PARADON MFG. Co., Arlington, N. J., has published a new bulletin No. 1-M, describing its direct feed solution feed chlorinators and, in addition, its thermal control chlorinators for smaller installations.

Seamless Metal Hose—CHAS. CORY & SON, INC., New York City, announces the distribution of the third edition of its hose bulletin describing its seamless flexible metal hose for conveying non-solids and non-abrasives. The bulletin describes and illustrates the hose and the various fittings available.

Motor Truck and Power Winches—SILENT HOIST WINCH AND CRANE Co., Brooklyn, N. Y., has issued a new bulletin No. 30, which features the different types and sizes of motor truck and power winches. Illustrations of the hoists and their uses are included.

Description of an Industrial Plant—McMYLER-INTERSTATE Co., Bedford, Ohio, has published a booklet entitled "A Trip Through One of Cleveland's Large Industrial Plants." By means of many illustrations the booklet gives an idea of the extent of the company's operation, its facilities and its line of products.

Compressors — INDEPENDENT PNEUMATIC TOOL Co., Chicago, illustrates and describes, in a new booklet, its portable air compressor equipped with a supercharger, explaining the mechanical details of the machine, and giving several pages of photographs of construction work upon which the compressors have been used.

Septic Tanks—STROUDSBURG SEPTIC-TANK Co., Philadelphia, has made available a new bulletin No. 100 describing its septic tanks for handling small sewage disposal work. The bulletin emphasizes the engineering service of the company rather than making claims for the septic tank itself. The booklet by means of diagrams, photographs and descriptive matter clearly shows the manner of installation and many of the types of manufacturing plants and buildings in which installations have been made.

Wire Glass—MISSISSIPPI WIRE GLASS Co., New York, has published a booklet of six pages, each page being devoted to a separate style of glass. Each page is a reproduction of one of the company's recent advertisements.

Concrete Pavement—AMERICAN VIBROLITHIC CORP., Des Moines, Iowa, has published a booklet containing a description of the various types of its vibrolithic pavement that are now in use, an illustrated description of the method of construction and a list of the communities in which such pavements have been constructed.

Induction Motors—RELIANCE ELECTRIC & ENGINEERING Co., Cleveland, Ohio, in its bulletin No. 101 describes its type AA induction motors for two and three phase a.c. circuits. The bulletin describes and illustrates the separate parts of the motor, its manner of construction and its applications. Tables are also given listing the company's squirrel cage motors for both 60 and 25 cycle operation.

Cast Iron Pipe Handbook—UNITED STATES CAST IRON PIPE AND FOUNDRY Co., Wellington, N. J., has published the more essential information that was contained in its general catalog, in a convenient pocket size. The handbook includes all the tables of water-works material found in the larger book, with the exception of the standards.

Material Handling Equipment—JEFFREY MFG. Co., Columbus, Ohio, has issued catalog 433, 46 pp., describing its various types of conveyors for material handling. These include apron conveyors, belt conveyors, scraper conveyors, bucket conveyors, assembly conveyors, garbage handling equipment, spiral conveyors, bucket elevators, arm elevators, tray elevators, bag stackers, portable bucket loaders, fans and blowers, coal and ash handling equipment.

Fire Detectors—GARRISON FIRE DETECTING SYSTEM, New York City, has published a 24-page booklet describing its system of fire alarms. The booklet describes the thermostatic wire which when it expands completes an electric circuit actuating the alarm bell. Illustrations and descriptions are given of the necessary pieces of equipment.

Accident Prevention — HERCULES POWDER Co., Wilmington, Del., has made a reprint of 13 safety articles which have appeared in the "Explosives Engineer" the title of the reprrint being "Preventing Accidents in Mines and Quarries."

Asphalt Plant—F. D. CUMMER & SON Co., Cleveland, Ohio, has published a 23-page booklet describing its asphalt plant equipped with the company's new type driers, mixers, dust chargers, and asphalt pumps. Illustrations and descriptions are given of road plants from 400 to 1,600 yd. capacity, and of the company's railroad-car steam-melting asphalt plant. The new driers and mixers are also illustrated and described, and many illustrations of accessories, tools and equipment are included.

Cement—VULCANITE PORTLAND CEMENT Co., has published a 9-page pamphlet describing its super cement, what it is and how it is manufactured to produce water proof and oil proof concrete. A list of the uses to which the cement has been put and some of the users' opinions are included.

Automatic Check Valve—THE AUTOMATIC CONE VALVE Co., Chicago, has made available a booklet explaining the principle of operation of its automatic cone check valve whose design is similar to that of a corporation cock but provides mechanical means for making the plug rotate freely. Besides a description of the operation and use of the valve, cross-sectional drawings are given of the valve and its parts.

Snow Plow—BAKER MFG. Co., Springfield, Ill., in its catalog No. 245 describes the company's snow plows for attachment to standard motor trucks. Various types of motor truck plows are listed and numbered. There are also included description and illustrations of various types of lifting frames the company furnishes for mounting plows on trucks.

Diesel Engines — WORTHINGTON PUMP & MACHINERY CORP., New York City, describes in its bulletin F-173, its double-acting, two-cycle Diesel engines. Following a brief résumé of the history of the Diesel engine and the method of operation of the various types, the double-acting, two-cycle Diesel engine is described and illustrated in detail. There is included a page giving a summary of shop tests of two of these engines which were built for the United States Shipping Board for marine service.

Manufacturers and Trade Associations

Calendar

Annual Meetings

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, New York; Annual convention, Pinehurst, N. C., Oct. 25-29.

NATIONAL ASSOCIATION OF MANUFACTURERS; Annual meeting, Chattanooga, Tenn., October 25, 26 and 27.

NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING. Sixth Annual Show. New York City, Dec. 5-10.

NATIONAL SAND AND GRAVEL ASSOCIATION, Washington, D. C.; Annual Convention, Detroit, Jan. 4-6, 1928.

ASSOCIATED EQUIPMENT DISTRIBUTORS, Milwaukee; Annual meeting, Cleveland, Jan. 6-7, 1928.

AMERICAN ROAD BUILDERS ASSOCIATION, Washington, D. C.; Annual Convention, Cleveland, Ohio, Jan. 9-14, 1928.

NATIONAL CRUSHED STONE ASSOCIATION, Washington, D. C.; Annual Convention, West Baden, Ind., Jan. 16-19, 1928.

Business Side of Construction

Facts and Events that Affect Cost and Volume

Contractors Travel Far to Get Big Jobs

That the contractor's sphere of operation is much broader than his home town in indicated by the fact that nearly 1,000 large contracts were taken since Jan. 1, 1927, by contractors located in states other than those in which the work was to be done. Since Sept. 1, there have been 164 such instances. A few of these follow:

Road Contracts in—	**Contractors** from—
Missouri	Iowa, South Dakota
Nevada	California
Massachusetts	Michigan
Kentucky	Missouri
Tennessee	Texas
New York	Connecticut
Alabama	Florida
Sewer Contracts in—	**Contractors** from—
New Jersey	Georgia
Texas	Illinois
Louisiana	Texas
Illinois	Minnesota-Iowa
Montana	Washington
Bridge Contracts in—	**Contractors** from—
Illinois	Iowa, Missouri
	Minnesota
Tennessee	Maryland, Georgia
	Alabama, Arkansas
Idaho	Oregon
Virginia	New York
	West Virginia
	No. Carolina
Oklahoma	Illinois
Water-Works Contracts in—	**Contractors from**—
Illinois	Wisconsin, Iowa
Kansas	Oklahoma
New Jersey	Pennsylvania
Missouri	Texas
Massachusetts	New York
Ontario	Illinois
Excavation Contracts in—	**Contractors from**—
Nova Scotia	Ontario
Louisiana	New York, Texas
	Nebraska
Mississippi	Louisiana
New Jersey	New York
Building Contracts in—	**Contractors** from—
Mississippi	Missouri
Florida	North Carolina
New Jersey	Ohio
Pennsylvania	Illnois
Texas	Mass., Penn.,
	New York
Missouri	New York
Federal Government Contracts in—	**Contractors** from—
Tennessee	New York
Virginia	Alabama
Mississippi	Arkansas
Arizona	Illinois
Alabama	Florida
	Dist. of Columbia
Connecticut	South Carolina
New Jersey	Nebraska

It is evident from the foregoing comparisons, that the movement of contractors in search of work, is by no means confined to one direction.

In road building, for instance, a job in New England was done by a Michigan contractor.

A New Jersey sewer contract was awarded to a Southern firm. New York bridge builders, on the other hand, got a job in Virginia. Excavation in Louisiana was also done by New York contractors. In buildings, there was considerable interchange between eastern and western contracting concerns.

Average Building and Construction Costs Same in September, 1927

Averaging the American Appraisal Company's index numbers of cost of four types of buildings in nine sections of the country gives the figure 204 for September, 1927. The *Engineering News-Record* index of general construction cost was 203.6 on September 1 and 204.4 on October 1, the average for September thus being 204.

The building indexes show brick with wood frame to be the costliest type of construction in every section of the country except Texas and the Pacific Coast states.

Building costs in the various sections of the country, according to these repricing indexes, are high in the following order: Pacific Coast states, 186; northwestern, 188; Texas, 195; Southeastern, 207.4; Centralwestern, 209.1; New England, 210; Pittsburgh district, 213.3; New York and North New Jersey, 213.6; Middle Atlantic, 214.5. The averages of the nine districts are:

Frame	204.8
Brick, wood frame	214.1
Brick, steel frame	196.6
Reinforced concrete	200.4

Following is a comparison of index numbers by sections:

1927	Frame	Brick, Wood Frame	Brick, Steel Frame	Reinforced Concrete
New England States				
1st Quarter Av..	204.0	217.0	199.0	203.2
2nd Quarter Av..	204.2	217.2	198.3	203.2
August	208.0	221.0	200.5	206.5
September	209.5	222.0	200.5	208.0
New York and Northern New Jersey				
1st Quarter Av..	207.9	227.2	207.0	213.5
2nd Quarter Av..	207.6	226.6	205.8	212.8
August	207.5	227.2	205.5	212.0
September	208.0	227.7	205.7	213.0
Middle Atlantic States				
1st Quarter Av..	211.0	229.9	209.0	207.6
2nd Quarter Av..	211.2	229.6	207.5	206.7
August	211.3	230.7	208.0	208.0
September	211.3	230.7	208.0	208.0
Pittsburgh District				
1st Quarter Av..	211.0	222.5	205.4	211.5
2nd Quarter Av..	212.5	222.9	204.4	210.8
August	213.8	224.2	204.2	210.5
September	213.8	224.5	204.5	210.5
Central Western States				
1st Quarter Av..	207.4	216.0	200.3	208.7
2nd Quarter Av..	208.0	217.2	200.1	209.2
August	209.0	218.0	199.8	209.5
September	209.0	218.2	199.8	209.5
Northwestern States				
1st Quarter Av..	186.3	194.0	185.3	184.0
2nd Quarter Av..	187.0	194.7	184.3	184.7
August	187.0	196.0	184.0	185.0
September	187.0	196.0	184.0	185.0
Texas				
1st Quarter Av..	205.0	202.0	187.7	186.7
2nd Quarter Av..	205.0	202.7	188.0	187.0
August	204.0	202.0	187.0	186.0
September	204.0	202.0	187.0	186.0
Southeastern States				
1st Quarter Av..	207.6	218.0	197.6	198.9
2nd Quarter Av..	207.7	217.7	196.6	198.7
August	210.0	220.0	197.5	201.5
September	210.0	220.0	197.5	202.0
Pacific Coast States				
1st Quarter Av..	191.8	189.8	184.0	183.5
2nd Quarter Av..	191.7	189.4	182.9	182.3
August	191.0	189.5	182.2	181.5
September	191.0	189.5	182.2	181.5

Foreign Projects of Interest to American Contractors

Opportunities open to American engineering and contracting organizations for work in foreign lands, are contained in the following proposals compiled by the Bureau of Foreign and Domestic Commerce, through the Industrial Machinery and Transportation Divisions. Further information may be obtained, in cases where a reference number is given, from the Bureau or its district and co-operative offices. This information, however, is confined to Americans qualifying for the Exporters' Index.

Canada—The following projects are proposed in various parts of the Dominion: A hotel, $10,000,000; two hotels, $1,000,000 each; hospital, $750,000; apartment house, $2,000,000. Canada No. 56,684. Six schools, Canada No. 56,683. The following are in British Columbia: A water tunnel, 13,200 ft. long, $13,000,000; lumber mill addition, $200,000; hospital addition, $200,000; sanitorium, $150,000 to $200,000. Canada No. 256,745.

China—Kai Tack reclamation project, Kowloon City, Hong Kong Government, 4,000,000 sq.ft. China No. 256,766.

Finland — Cellulose factory, Veitsiluoto, Government of Finland, estimated, $1,511,353.

Australia — Office building, Sydney, £620,000. Australia No. 56,467.

The program for road construction in the State of South Australia, for the year ending June 30, 1928 (£399,000), has been approved.

Brazil—Museum, Bahia, $94,400, communicate with Secretaria da Agricultura do Estado da Bahia, Bahia, Brazil.

Egypt—Irrigation projects: (1) Nag Hamadi dam, approximately $15,000,000; (2) special appropriation for raising Assuan dam 9 or 10 ft. higher.

Argentine — Maintenance of over 2,000 kilometers of roads and highway bridges. Expenditure of $785,700, authorized by Minister of Public Works.

France—Port development plans for the city of Marseille completed. The work will cost 52,000,000 francs and include: modification of the Joliette basin; construction of five new basins; a breakwater; two freight depots; and quays.

Correction in Cement Prices at Detroit

The price of cement at Detroit given in *Engineering News-Record*, issue of Oct. 6, 1927, p. 574, under the caption One Month Ago, should have read $2.15 per bbl. instead of $2.20. This would constitute a reduction of only 15c. per bbl., compared with 20c. as at first indicated.

This Week's Contracts—With Comparisons

Minimum costs observed are: $15,000 for water-works and excavation, drainage, irrigation, levee, river and harbor projects; $25,000 for other public works; $40,000 for industrial and $150,000 for commercial, educational, institutional, religious and other buildings.

Week ended	Public Work	Private Work	Total U. S.
October 20, 1927...	$40,273,000	$18,870,000	$59,143,000
October 13, 1927...	29,761,000	19,404,000	49,165,000
October 21, 1926...	21,791,000	41,944,000	63,735,000
Jan. 1 to date			
1927	1,059,965,000	1,483,361,000	2,543,326,000
1926	910,562,000	1,439,756,000	2,350,316,000

E.N.-R. Index Numbers

On October 1, 1927

COST	VOLUME
204.40	273
Last Year 209.80	Last Year 227

The Index Numbers are published in detail and with charts in the first issue of each month. The Cost Index is given in full from 1903 through 1926, with a thorough explanation of its method of computation, and a graphic comparison with many other index numbers, in the 48-page pamphlet entitled Engineering News-Record Construction Costs.

Weekly Construction Market

	New York	Atlanta	Dallas	Chicago	Minneapolis	Denver	San Francisco	Seattle	Montreal
Steel Products									
Structural shapes, per 100 lb....	$3.34	$3.75	$4.00	$3.10	$3.35	$3.87½	$3.00	$3.00	$4.00
Structural rivets, per 100 lb....	5.00	4.00	4.75	3.60	3.85	4.64	5.50	5.25	5.50
Reinforcing bars, per 100 lb....	3.24	2.99	2.75	2.50	2.87½	3.77½	2.95	3.00	3.57
Steel pipe, black, 2½ to 6 in., lap weld, discount from list	48%	40%	54%	51%	48%	41%	42@53.8%	48%	.....
Cast-iron pipe, 6 in. and over, per net ton	42.60	36.50	54.00	38.20	42.50	—54.00	41.00	55.00	41.00
Concreting Material									
Cement, without bags, per bbl. .	2.35†	2.40	2.05	2.05	2.22	2.85	2.51	2.65	1.41
Gravel, ¾ in., per cu.yd.....	1.75	2.20*	2.38	2.00	1.25*	1.90	1.80	1.25	1.90*
Sand, per cu.yd.	1.00	1.75	2.00	2.00	1.25†	1.00	1.40	1.25	1.35*
Crushed stone, ¾ in., per cu.yd...	1.85	2.50*	2.83	2.00	1.25*	2.50	1.70	—2.50	2.00*†
Miscellaneous									
Fir, 3x12 to 12x12, 20 ft. and under, per M.ft. b.m.	.....	.....	.....	39.50(S4S)	36.75@ 38.75	34.25	27.00	24.00	55.00†
Pine, 3x12 to 12x12, 20 ft. and under, per M.ft. b.m.....	65.00@62.00†	34.00	56.00†	.....	.....	.....	.....	.....	.....
Lime, finishing, hydrated, ton...	19.45	24.50	19.00	20.00†	25.50	24.00	27.50	24.00	21.00
Lime, common, lump, per bbl ..	2.35@2.50‡	1.35	1.82	1.50†	1.70	2.70‡	1.70	2.80‡	10.00*
Common brick, per M	16.00@18.00†	12.50	13.60	12.00†	13.75†	8@12	14.00	14.00	20.25
Hollow building tile, 4x12x12, per block	Not used	.0724†	.103	.....	.072	.085	..	.10	.10
Hollow partition tile, 4x12x12, per block	.1027	.0724†	.103	.076†	.072	085	.108	.09	.08
Linseed oil, raw, 5 bbl. lots, per 7½-lb. gal.	.86¼	.87	.85	.79	—.87	—.91	.92	.98	1.03
Common Labor									
Common labor, union, per hour.	.90⅝	.30	.....	.90	.....	.....	.62½	.70	.....
Common labor, non-union, hour.	.....	.25	.30@.50	.82½	.45@.60	.31¼@.50	....	.62½	.30@.35

*Ton. †Delivered to job. ‡280-lb. net. +Advance. —Decline.

PRICES of building materials, as a group, average for the entire country, have shown two declines to each advance, since January, 1926.

Lumber, brick, structural steel, and paint materials, taken separately, experienced three price reductions to every rise, during the months in question.

It remains for cement to show the highest ratio of recessions to increases, for the period, Jan. 1, 1926, to date.

Building materials, other than the five mentioned, did not differ greatly from all building materials, taken together, so far as ratio of declines to advances is concerned.

It would appear from the price fluctuations mentioned, that the general trend of the building materials market is downward. Most of the advances referred to, occurred in the early spring or mid-summer of this year and last. The declining price tendency is nation-wide in effect, despite the fact that money spent for heavy engineering construction, thus far this year, exceeds the contract value for the corresponding period in 1926.

THIS limited price list is published weekly except in the first issue of each month and gives current prices on the principal construction materials in the chief cities. Valuable suggestions on costs of work can be had by noting actual biddings as reported in the Construction News and Unit Prices sections following.

The first issue of each month carries complete quotations for all of the basic materials and for the rest of the important cities, also wage rates for the principal building trades and common labor. The last complete list will be found in the issue of Oct. 6, the next on Nov. 3. Explanation of prices contained in the table will appear from time to time in this section; last shown Aug. 11, 1927, p. 247.

Price changes of the week, in the fifteen materials at nine important cities, show the following declines: Cast-iron pipe $2.50 per ton at Denver; crushed stone, ¾-in., 50c. per cu.yd. at Seattle; linseed oil, 1¼c. per 7½-lb. gal. at Minneapolis, and 8c. f.o.b. Denver.

Declining tendencies are very marked, this week, in prices of coke, scrap, and pig-iron at the principal centers of distribution, throughout the country. Demand is slower for steel structurals and bars but without actual price change. The principal reductions in metals prices, compared with Oct. 7 levels, were in No. 2 foundry pig iron at Chicago; iron machinery castings at Cincinnati; black steel sheets, f.o.b. Pittsburgh mills; and solder at New York warehouses.

Steel reinforcing bars, structural shapes, and plates continue at $1.75 per 100 lb., base, Pittsburgh, for large tonnages. The price on single carloads is $1.85 per 100 lb., f.o.b., mill. The present level of quotations for the principal hot-rolled steel products is about 25c. per 100 lb. below that of a year ago; no change occurred during the month.